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U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service

In August 1959, the President directed the Secretary of Health, Education, and Welfare to intensify departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis, and interpretation of data on environmental radiation levels. The Department delegated this responsibility to the Division of Radiological Health, Public Health Service.

Radiological Health Data is published by the Public Health Service on a monthly basis. Data are provided to the Division of Radiological Health by other Federal agencies, State health departments, and foreign governments. Except where material is directly quoted or otherwise credited, summaries and abstracts are prepared by the staff of the Data Collation and Analysis Unit, Division of Radiological Health. The reports are reviewed by a Board of Editorial Advisers with representatives from the following Federal agencies:

Department of Health, Education, and Welfare
Atomic Energy Commission
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RADIOLOGICAL HEALTH DATA

MONTHLY REPORT MAY 1961

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U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE

Public Health Service • Division of Radiological Health

SECTION I.—AIR

Radiation Surveillance Network

Division of Radiological Health, Public Health Service

The Public Health Service Radiation Surveillance Network was established in 1956 in cooperation with the Atomic Energy Commission to provide a means of promptly determining increases in levels of environmental radioactivity due to fallout from nuclear weapons tests. Although no nuclear tests have been conducted by the United States since 1958, the program has proved sufficiently valuable that it has been extended to a year-round basis. Currently, it consists of 45 stations at urban locations (see fig. 1) operated by State and local health department personnel with 2 of the stations operated by Public Health Service personnel.

Measurements of gross beta radioactivity in air have been taken since they provide one of the earliest and most sensitive indications of increases of activity in the environment and thus act as an "alert" system. A direct evaluation of biological hazards is not possible from these data alone. Field measurements enable the operator to estimate the amount of beta activity of particulates in air at the station 5 hours after collection by comparison with a known source using a portable survey meter. The filters are then forwarded to the central laboratory of the Radiation Surveillance Network in Washington, D.C., for a more refined measurement using a thin window proportional counter. The stations located at Atlanta, Ga., and Cincinnati, Ohio, conduct their own laboratory analyses.

Air samplers are in operation at the 45 stations on an average of 70 percent of the week. Air is drawn through a carbon-loaded cellulose dust filter using a high volume air sampler. The radioactive material in fallout adhering to small particles is retained on the filter. Some gaseous fission products are adsorbed by the carbon. The contribution by gaseous fission products has represented only a small part of the total beta activity in these samples. About 85 percent of the stations collected samples of precipitation which are sent to Washington, D.C., for analysis. Values are now below limits of detection by present instrumentation.

Tables 1 and 2 summarize the data for December 1960.

FIGURE 1.—RADIATION SURVEILLANCE NETWORK SAMPLING STATIONS.

TABLE 1.—RADIOACTIVITY OF PARTICULATES IN AIR—GROSS BETA DETERMINATIONS

Radiation Surveillance Network, Public Health Service, December 1960

Station location	Number of samples	Maximum ($\mu\mu c/m^3$)	Minimum ($\mu\mu c/m^3$)	Weighted average ($\mu\mu c/m^3$)	Station location	Number of samples	Maximum ($\mu\mu c/m^3$)	Minimum ($\mu\mu c/m^3$)	Weighted average ($\mu\mu c/m^3$)
Anchorage, Alaska	21	<0.10	<0.10	<0.10	Pascagoula, Miss	19	0.18	<0.10	<0.11
Fairbanks, Alaska	21	<.10	<.10	<.10	Jefferson City, Mo	21	<.10	<.10	<.10
Juneau, Alaska	16	<.10	<.10	<.10	Helena, Mont	20	<.10	<.10	<.10
Phoenix, Ariz	2	<.10	<.10	<.10	Trenton, N.J	1	<.10	<.10	<.10
Little Rock, Ark	20	<.10	<.10	<.10	Santa Fe, N. Mex	15	.13	<.10	<.10
Berkeley, Calif	21	.13	<.10	<.10	Albany, N.Y	26	.16	<.10	<.10
Los Angeles, Calif	21	.16	<.10	<.11	Gastonia, N.C	16	.20	<.10	<.11
Denver, Colo	21	.15	<.10	<.10	Cincinnati, Ohio	21	.19	.02	.06
Hartford, Conn	31	.11	<.10	<.10	Oklahoma City, Okla	15	.10	<.10	<.10
District of Columbia	25	.14	<.10	<.10	Ponca City, Okla	30	<.10	<.10	<.10
Jacksonville, Fla	20	<.10	<.10	<.10	Portland, Oreg	20	.17	<.10	<.11
Atlanta, Ga	14	.12	.03	.07	Harrisburg, Pa	13	.11	<.10	<.10
Honolulu, Hawaii	21	<.10	<.10	<.10	Providence, R.I	21	.17	<.10	<.10
Boise, Idaho	3	<.10	<.10	<.10	Columbia, S.C	7	<.10	<.10	<.10
Springfield, Ill	15	<.10	<.10	<.10	Pierre, S. Dak	5	<.10	<.10	<.10
Indianapolis, Ind	30	<.10	<.10	<.10	Austin Tex	19	<.10	<.10	<.10
Iowa City, Iowa	19	<.10	<.10	<.10	El Paso, Tex	20	.24	<.10	<.13
Topeka, Kans	20	<.10	<.10	<.10	Salt Lake City, Utah	31	.12	<.10	<.10
New Orleans, La	4	<.10	<.10	<.10	Richmond, Va	21	.12	<.10	<.10
Baltimore, Md	20	.11	<.10	<.10	Seattle, Wash	21	.10	<.10	<.10
Lawrence, Mass	20	<.10	<.10	<.10	Cheyenne, Wyo	9	<.10	<.10	<.10
Lansing, Mich	29	<.10	<.10	<.10	Madison, Wis	17	<.10	<.10	<.10
Minneapolis, Minn	9	<.10	<.10	<.10					

TABLE 2.—RADON AND THORON MEASUREMENTS

Public Health Service Radiation Surveillance Network, Station at Cincinnati, Ohio, December 1960

Day	Continuous sample collection			Radon [a] a.m. ($\mu\mu c/m^3$)	Radon-thoron [b] p.m. ($\mu\mu c/m^3$)	Thoron [c] ($\mu\mu c/m^3$)	Beta [d] activity ($\mu\mu c/m^3$)	Day	Continuous sample collection			Radon [a] a.m. ($\mu\mu c/m^3$)	Radon-thoron [b] p.m. ($\mu\mu c/m^3$)	Thoron [c] ($\mu\mu c/m^3$)	Beta [d] activity ($\mu\mu c/m^3$)
	Sample change time	Sample period (hours)	Volume (m^3)						Sample change time	Sample period (hours)	Volume (m^3)				
1	0815	23.90	28.29	160	100	2.2	0.13	19	0828	72.10	85.93	210	130	2.4	0.06
2	0822	24.09	27.49	320	60	4.2	.03	20	0823	23.88	28.59	240	100	.8	.02
5	0822	71.99	83.99	380	90	8.9	.07	21	0825	24.00	28.54	120	300	1.2	.00
6	0815	23.87	29.09	250	120	4.4	.19	22	0823	23.95	28.87	240	150	1.1	.13
7	0835	24.30	28.59	290	160	3.0	.14	23	0838	24.23	30.07	250	130	1.2	.00
8	0821	23.73	27.28	360	160	3.8	.14	27	0808	95.46	113.81	40	170	1.0	.03
9	0814	23.86	28.15	300	160	2.6	.07	28	0807	23.95	29.27	220	30	.07	.03
12	0842	72.45	86.82	100	90	2.7	.05	29	0812	24.07	28.91	430	190	1.1	.04
13	0835	23.86	29.19	210	50	1.1	.08	30	0812	23.97	28.99	170	210	1.4	.12
14	0823	23.76	28.81	190	60	1.4	.05	Jan. 3, 1961	0810	95.95	113.90	190	160	.8	.04
15	0827	24.03	29.17	160	140	1.6	.05								
16	0820	23.85	29.14	110	150	1.7	.07	Average				210	130	2.4	.06

[a] Radon concentrations are derived from alpha measurements determined immediately after the sampling period (24 to 96 hours) has ceased. Reported radon concentrations have been corrected for any thoron daughter interferences. Twice the standard deviation (2σ) falls between ± 10 and ± 40 $\mu\mu c/m^3$.

[b] Radon concentrations are derived from alpha measurements made in the afternoon (3 p.m.) approximately 7 hours after the new sampling period has begun. Therefore, the reported values were actually determined one day prior to the date reported here. Reported radon concentrations are uncorrected for any thoron daughter interferences. Twice the standard deviation (2σ) falls between ± 10 and ± 30 $\mu\mu c/m^3$.

[c] Thoron concentrations are derived from alpha measurements referred to in footnote (a) but are counted 7 hours after the sampling period (24 to 96 hours) has ceased. The values reported here have been corrected to the time of removal from the filter holder. Twice the standard deviation (2σ) falls between ± 0.1 and ± 0.5 $\mu\mu c/m^3$.

[d] Gross beta concentrations are based on measurements made at least 4 days after each sampling period (24 to 96 hours) has ceased. Twice the standard deviation (2σ) falls between ± 0.07 and ± 0.08 $\mu\mu c/m^3$.

Radioactivity Measurements in Air

U.S. Naval Research Laboratory

Radioactivity measurements of air-filter samples collected at various sites near the 80th Meridian (West) are made by the U.S. Naval Research Laboratory under a program partially financed by the Atomic Energy Commission.

The daily record of fission product beta activity during December 1960 is presented in table 1, and the radioactivity profile for the same month is shown in figure 1. This figure now illustrates the data plotted in semilogarithmic coordinates. Previously the data were presented in rectangular coordinates with the abscissa expressed in disintegrations per minute per cubic meter. The concentrations in table 1 are expressed in disintegrations per minute per cubic meter of air at the collecting site (2.2 disintegrations per minute per cubic meter equals 1 micromicrocurie per cubic meter).

TABLE 1.—DAILY RECORD OF FISSION PRODUCT BETA ACTIVITY COLLECTED BY AIR FILTRATION

U.S. Naval Research Laboratory, December 1960

[Disintegrations/minute per cubic meter]

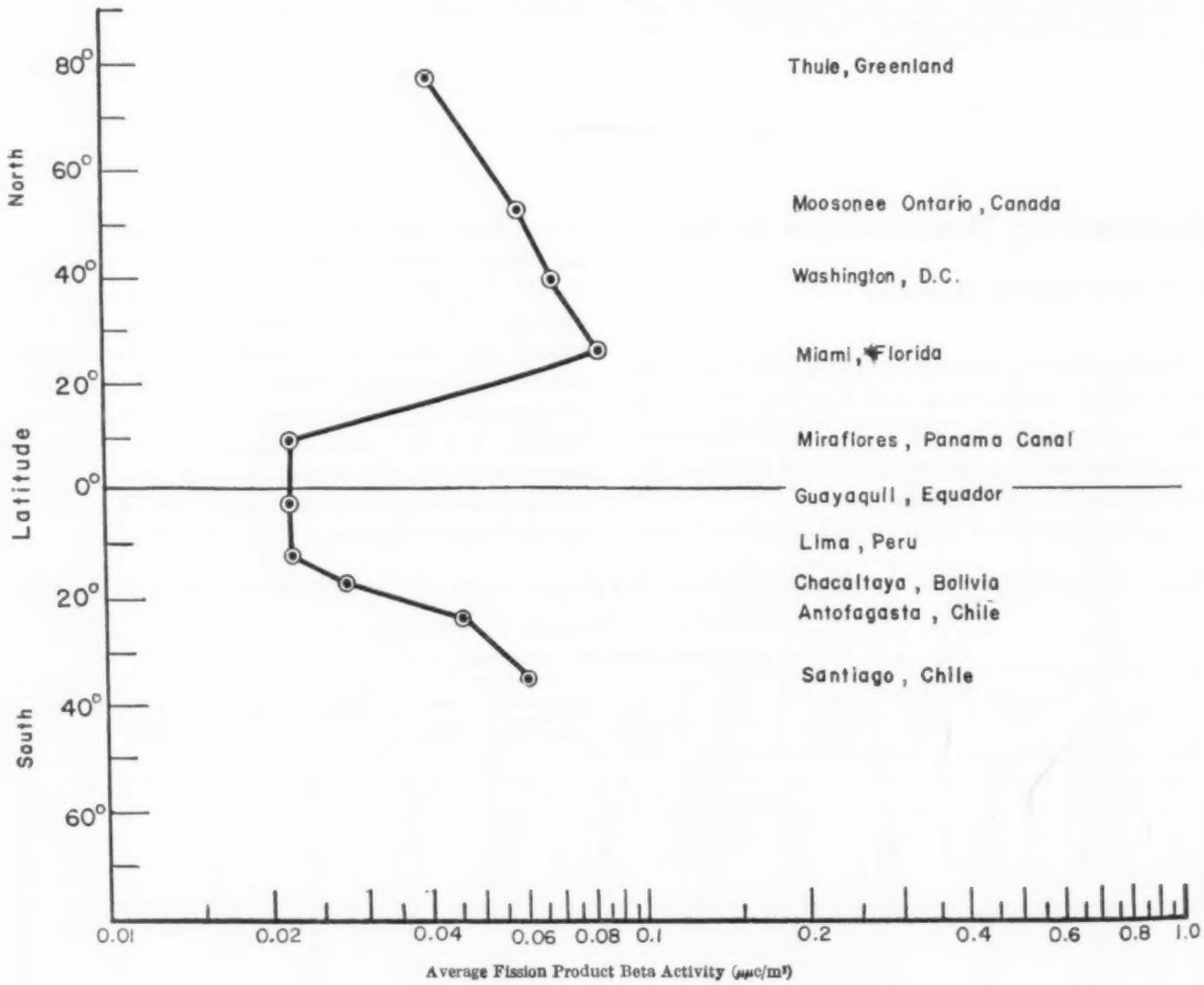
Day	Santiago, Chile	Antofagasta, Chile	Chacaltaya, Bolivia	Lima, Peru	Guayaquil, Ecuador	Miraflores, Panama Canal Zone	Mauna Loa, Hawaii	Miami, Fla.	Washington, D.C.	Moosonee, Ontario, Canada	Thule, Greenland
1	0.07	----------	0.07	----------	0.04	0.01	0.04	0.19	0.06	0.10	0.10
2	.07	----------	.07	----------	.04	.01	.04	.19	.06	.10	.07
3	.13	0.16	.06	0.03	.05	.01	.03	.11	.10	.18	.07
4	.13	.16	.08	.03	.05	.01	.03	.11	.10	.18	.10
5	.13	.16	.06	.03	.06	.01	.03	.11	.10	.18	.10
6	.22	.10	.04	.05	.06	.03	.11	.17	.14	.15	.04
7	.22	.10	.05	.05	.03	.03	.11	.17	.14	.15	.04
8	.06	.12	.07	.04	.03	.03	.09	.14	.14	.13	.04
9	.06	.12	.04	.04	.03	.03	.09	.14	.14	.13	.08
10	.08	.13	.03	----------	.03	.04	.08	.10	.13	.12	.08
11	.08	.13	.04	----------	.03	.04	.08	.10	.13	.12	.14
12	.08	.13	.06	----------	.07	.04	.08	.10	.13	.12	.14
13	.20	.13	.08	.08	.07	.02	.05	.20	.26	.14	.15
14	.20	.13	.07	.08	.07	.02	.05	.20	.26	.14	.13
15	.10	.06	.06	.13	.07	.02	.06	----------	.23	.28	.13
16	.10	.06	.04	.13	.07	.02	.06	----------	.23	.28	.12
17	.08	.06	.05	.03	----------	.04	.04	.33	.17	.13	.12

TABLE 1. DAILY RECORD OF FISSION PRODUCT BETA ACTIVITY COLLECTED BY AIR FILTRATION—Continued

Day	Santiago, Chile	Antofagasta, Chile	Chacaltaya, Bolivia	Lima, Peru	Guayaquil, Ecuador	Miraflores, Panama Canal Zone	Mauna Loa, Hawaii	Miami, Fla.	Washington, D.C.	Moosonee, Ontario, Canada	Thule, Greenland
18	0.08	0.06	0.06	0.03	----------	0.04	0.04	0.33	0.17	0.13	0.11
19	.08	.06	.05	.03	----------	.04	.04	.33	.17	.13	.11
20	.16	.08	.04	.03	----------	.04	.06	.24	.13	.09	.11
21	.16	.08	.06	.03	----------	.04	.06	.24	.13	.09	.05
22	.29	.09	.10	.05	----------	.05	.06	----------	.12	.10	.06
23	.29	.09	.09	.05	----------	.05	.06	----------	.12	.10	.05
24	.08	.09	.11	.02	----------	.05	.03	.27	.19	.10	.05
25	.08	.09	.07	.02	----------	.05	.03	.27	.19	.11	.05
26	.08	.09	.07	.02	0.03	.05	.03	.27	.19	.11	.05
27	.17	.10	.04	.08	.03	.10	.04	.19	.15	----------	.05
28	.17	.10	.01	.08	.06	.10	.04	.19	.15	----------	.05
29	----------	.10	.01	----------	.06	.14	.04	.08	.13	.08	.05
30	----------	.10	.02	.08	.07	.14	.04	.08	.13	.08	.11
31	----------	.13	.02	.08	.07	.14	.03	.08	.11	.07	.11
Mean value	.13	.10	.06	.05	.05	.05	.05	.18	.15	.13	.09

FIGURE 1.—PROFILE OF BETA ACTIVITY

Average Measurements of Surface Air at Stations Near the 80th Meridian (West), U.S. Naval Research Laboratory
December 1960



SECTION II.—MILK

Milk Monitoring Program

Division of Radiological Health, Public Health Service

The original Public Health Service Milk Monitoring Program consisted of 12 sampling stations, of which 9 are still active. Raw milk is spot sampled at these stations. During 1960 a new sampling program of 60 stations was established. Processed milk is sampled at these stations. Since the sampling procedures for the raw milk sampling stations and the processed milk area sampling stations are different, they are described and reported separately. The Public Health Service Robert A. Taft Sanitary Engineering Center, Cincinnati, Ohio, continues to conduct the analyses for the original network stations; the Public Health Service Southeastern Radiological Health Laboratory at Montgomery, Ala., and the Southwestern Radiological Health Laboratory at Las Vegas, Nev., provide analytical services for the new program.

The purposes of the two sampling programs are not the same. The original network was established to develop sampling and radiochemical analytical proficiencies under conditions which would remain similar over a period of time in regard to the source of milk. During the operation of this program it became apparent that a broader sampling program, more directly related to the milk consumed by the population, was necessary. The Public Health Service and the Department of Health, Education, and Welfare acted to provide facilities for this change. This resulted in the transition from the program of sampling raw milk, collected from milksheds of limited size, to a sampling program designed to be representative of the processed milk consumed in a given municipality.

In some instances, the newly designated stations are the same as those which were reported originally. The establishment of the new processed milk area sampling stations does not preclude the need for further raw milk sampling from the selected milkshed serving the same city. It is important that both networks be in operation for a sufficient period of time to provide an overlap for the purpose of comparative study.

Because of the different sources of these samples, changes in the method of collecting samples, and the utilization of different laboratory techniques, differences were anticipated in the amounts of radioactivity found in the milk under the two programs. For this reason, an investigation to determine the comparability of the two programs was begun in January 1961. This investigation covers many factors, including laboratory methodology and collection methods. Until this study has been completed and additional experience has been gained under the new program, no valid interpretation can be made of any differences of radioactivity in milk samples collected under the two systems.

Publication of the data will normally follow about 4 months after collection of samples because of the time required for shipment, processing, decay product buildup, compilation of the data, and clearance and publication procedures.

Raw Milk Sampling Stations

The initial purpose of establishing this network was in keeping with the normal and continuing program of the Public Health Service to determine trends in our changing environment with respect to measuring the amounts of radioactivity in water, air, milk, and other foods. Milk was the food chosen for initial testing because it is among the most important components of the diet and is available at all seasons of the year and in all climates. A primary objective of the project was to develop effective collection systems and radiochemical analysis procedures which would make them more suitable for larger scale programs.

The criteria on which the selection of the original sampling stations was based appeared in the discussion sections of all Volume I issues of *Radiological Health Data*.

One-gallon raw milk samples are collected once each month and forwarded by air parcel post to the Robert A. Taft Sanitary Engineering Center for radionuclide analyses. It is estimated that these samples represent 2,000-gallon lots. The concentrations of iodine-131, barium-140, cesium-137, and naturally occurring potassium-40 are all currently being measured by gamma scintillation spectroscopy. Total radiostrontium and strontium-90 are determined following radiochemical separations. The amount of strontium-90 is calculated by measuring the buildup of the strontium-90 daughter decay product, yttrium-90, over a 2-week period. Measurements are made with a low background anticoincidence beta counter. The total radioactive strontium is counted in a shielded internal proportional counter with the strontium-89 calculated as the difference between this value and strontium-90. Stable calcium is also determined.

April through September 1960 issues of *Radiological Health Data* list references for technical descriptions of the methodology of analyses used.

December data for the raw milk sampling stations are presented in table 1.

Processed Milk Area Sampling Stations

The monitoring of milk has been expanded to provide additional information on levels of radioactivity in milk consumed by the public. The new stations have been established in cooperation with State and local health and milk sanitation agencies. Each city has been selected to provide adequate coverage with respect to production areas and the consuming population. The emphases on this expanded sampling and radioassay program are—

1. Measuring the radioactivity levels of the milk consumed by the public in various regions of the country by obtaining samples of pasteurized and homogenized milk at the processing plant, and
2. Providing one sampling point within each State with additional points when indicated by widely varying conditions of the milk supply or the need to provide coverage of large population groups. This differs from the original set of sampling stations whose selection was based principally upon certain criteria involving milk production and milkshed area characteristics.

The new network was designed to sample processed milk rather than the raw product. The sampling procedure was developed to provide a sample from 1 day's sales per month in a community which would be as representative of the total supply as can be achieved under practical conditions. Each sample is a composite of those plants supplying not less than 90 percent of a city's milk supply. The contribution from each plant to the total sample is approximately proportional to volume of milk sold.

The samples from the new stations are collected with the assistance of the various State and local health and milk sanitation agencies and are shipped for analyses to either the Southwestern or Southeastern Radiological Health Laboratory. The Southeastern Radiological Health Laboratory processes samples from the 30 States generally east of the Mississippi, and the Southwestern Radiological Health Laboratory processes samples from the Western States. Figure 1 shows the locations of these stations.

At the present time radioassays for Sr^{89}, Sr^{90}, Cs^{137}, Ba^{140}, and I^{131} are being performed. To date, the latter two isotopes have been below present limits of detection. Other radionuclides of concern to public health agencies will be included for assay as necessary for more complete monitoring of the milk supply.

December data from the two laboratories are presented in table 2.

TABLE 1.—RADIOACTIVITY IN MILK—RAW MILK SAMPLING STATIONS, DECEMBER 1960

Milk Monitoring Program, Public Health Service, Robert A. Taft Sanitary Engineering Center

[Radioactivity concentrations in μμc/liter]

Area	Calcium (grams/liter)		Iodine-131		Strontium-89		Strontium-90		Barium-140		Cesium-137	
	December	Yearly average	December	Yearly average	December	Yearly average	December	Yearly average	December	Yearly average	December	Yearly average
Atlanta, Ga.	1.25	1.13	ND [1]	<10	ND	<5	11	15	ND	<10	20	35
Austin, Tex.	1.15	1.11	ND	<10	ND	<5	4	4	ND	<10	10	15
Chicago, Ill.	1.10	1.10	ND	<10	ND	<5	8	9	ND	<10	15	30
Cincinnati, Ohio	1.18	1.13	ND	<10	ND	<5	7	10	ND	<10	20	25
New York, N.Y.	1.11	1.10	ND	<10	ND	<5	8	9	ND	<10	15	25
Sacramento, Calif.	1.21	1.12	ND	<10	ND	<5	2	3	ND	<10	5	10
Salt Lake City, Utah	1.17	1.11	ND	<10	ND	<5	5	6	ND	<10	5	30
Spokane, Wash.	1.24	1.13	ND	<10	ND	<5	6	11	ND	<10	20	35
St. Louis, Mo.	1.30	1.22	ND	<10	ND	<5	14	18	ND	<10	15	30

[1] ND—No detectable activity.

FIGURE 1.—PROCESSED MILK AREA SAMPLING STATIONS

TABLE 2.—RADIOACTIVITY IN MILK—PROCESSED MILK AREA SAMPLING STATIONS, DECEMBER 1960

Milk Monitoring Program, Public Health Service

[Radioactivity concentrations in μμc/liter]

Area	Number [1] of months reported	Calcium (grams/liter)		Strontium-89		Strontium-90		Cesium-137	
		December	Average to date	December	Average to date	December	Average to date	December	Average to date
Albuquerque, N. Mex.	10	1.14	1.10	ND [2]	<5	6	4	ND	5
Atlanta, Ga.	5	1.24	1.24	ND	<5	8	10	ND	<5
Austin, Tex.	7	1.29	1.18	ND	<5	2	2	ND	5
Baltimore, Md.	5	1.21	1.16	ND	<5	10	8	ND	<5
Boston, Mass.	7	1.25	1.19	ND	<5	10	12	ND	15
Buffalo, N.Y.	7	1.21	1.18	ND	<5	8	7	ND	<5
Burlington, Vt.	9	1.22	1.20	ND	<5	8	9	ND	10
Charleston, S.C.	5	1.40	1.27	ND	<5	12	10	ND	5
Charleston, W. Va.	9	1.28	1.18	ND	<5	9	9	ND	<5
Charlotte, N.C.	7	1.29	1.23	ND	<5	12	12	ND	5
Chattanooga, Tenn.	4	1.34	1.31	ND	<5	10	10	ND	<5
Chicago, Ill.	6	1.20	1.15	ND	<5	6	6	ND	<5
Cincinnati, Ohio	5	1.27	1.18	ND	<5	8	8	ND	<5
Cleveland, Ohio	6	1.23	1.16	ND	<5	7	8	ND	<5
Dallas, Tex.	7	1.30	1.22	ND	<5	6	6	ND	<5
Denver, Colo.	10	1.14	1.10	ND	<5	10	7	10	10
Des Moines, Iowa	7	[3]	1.04	[3]	<5	[3]	8	[4]	15
Detroit, Mich.	6	1.20	1.16	ND	<5	8	7	ND	<5
Grand Rapids, Mich.	6	1.32	1.25	ND	<5	6	7	30	5
Hartford, Conn.	9	1.24	1.19	ND	<5	8	9	ND	10
Helena, Mont.	7	1.22	1.08	ND	<5	5	6	ND	10
Honolulu, Hawaii	9	1.16	1.07	ND	<5	4	5	ND	20
Idaho Falls, Idaho	10	1.12	1.07	ND	<5	4	5	10	20
Indianapolis, Ind.	6	1.24	1.20	ND	<5	7	6	ND	<5
Jackson, Miss.	5	1.36	1.31	ND	<5	14	12	ND	<5
Kansas City, Mo.	9	1.08	1.06	ND	<5	7	8	ND	10
Laramie, Wyo.	9	1.14	1.06	ND	<5	6	5	10	10
Las Vegas, Nev.	8	1.01	1.05	ND	<5	4	3	ND	<5
Little Rock, Ark.	5	[4]	1.21	[4]	<5	[4]	13	[4]	<5
Louisville, Ky.	9	1.24	1.19	ND	<5	8	9	ND	<5
Manchester, N.H.	9	1.24	1.22	ND	<5	8	11	20	25
Memphis, Tenn.	4	1.27	1.26	ND	<5	9	10	ND	<5
Milwaukee, Wis.	6	1.25	1.17	ND	<5	5	6	ND	<5
Minneapolis, Minn.	5	1.11	1.05	ND	<5	8	8	ND	<5
New Orleans, La.	6	1.24	1.25	ND	<5	10	13	ND	<5
New York, N.Y.	7	1.24	1.14	ND	<5	7	9	ND	5
Norfolk, Va.	6	1.28	1.20	ND	<5	11	9	ND	<5
Oklahoma City, Okla.	6	1.16	1.18	ND	<5	6	8	ND	<5
Omaha, Nebr.	5	1.06	1.04	ND	<5	7	7	ND	5
Palmer, Alaska	10	1.08	1.07	ND	<5	6	7	ND	10
Philadelphia, Pa.	7	1.26	1.17	ND	<5	7	8	ND	10
Phoenix, Ariz.	6	1.15	1.02	ND	<5	5	4	ND	15
Pittsburgh, Pa.	9	1.23	1.22	ND	<5	12	12	ND	5
Portland, Maine	7	1.18	1.14	ND	<5	8	11	10	15
Portland, Oreg.	9	1.29	1.12	ND	<5	11	10	10	30
Providence, R.I.	7	1.40	1.21	ND	<5	8	11	5	10
Sacramento, Calif.	5	1.14	1.06	ND	<5	6	5	ND	<5
Salt Lake City, Utah	10	1.14	1.09	ND	<5	5	6	ND	5
San Francisco, Calif.	7	1.22	1.11	ND	<5	6	4	ND	10
San Juan, P.R.	6	1.18	1.16	ND	<5	4	4	ND	<5
Seattle, Wash.	9	1.21	1.09	ND	<5	7	8	10	30
Spokane, Wash.	8	1.23	1.09	ND	<5	6	7	10	20
St. George, Utah	5	1.10	1.04	ND	<5	5	5	ND	5
St. Louis, Mo.	5	1.10	1.05	ND	<5	10	7	20	35
Syracuse, N.Y.	9	1.28	1.23	ND	<5	6	7	ND	10
Tampa, Fla.	5	1.28	1.26	ND	<5	6	5	50	75
Trenton, N.J.	7	1.47	1.22	ND	<5	6	8	ND	5
Washington, D.C.	6	1.31	1.17	ND	<5	6	8	ND	<5
Wichita, Kans.	9	1.16	1.08	ND	<5	6	6	ND	<5
Wilmington, Del.	7	1.24	1.21	ND	<5	8	8	ND	10

[1] Because this program was initiated in 1960 and sampling stations necessarily became operative in a staggered sequence, the averages shown represent all samples taken to date, but the months may not necessarily be consecutive.

[2] ND—No detectable activity.
[3] Sample curdled in shipping.
[4] Sample lost.

SECTION III.—WATER

National Water Quality Network

Division of Water Supply and Pollution Control
Public Health Service

The National Water Quality Network was established under the provision of section 4(c) of Public Law 660, which states "* * * The Surgeon General shall * * * collect and disseminate basic data * * * [relating] to water pollution and the prevention and control thereof."

This network, operated in cooperation with State and local health agencies, was started in October 1957. At present, there are 75 sampling stations located on major waterways used for public water supply, propagation of fish and wildlife, recreational purposes, and for agricultural, industrial and other uses. Some of these stations are on interstate, coastal, and international boundary waters, and waters on which activities of the Federal Government may have an impact. Ultimately, a total of 250 to 300 stations will be in operation. A few of the more recently established stations have not begun to report radioactivity.

Samples of water are examined for chemical, physical, and biological quality insofar as these relate to pollution. Samples for some determinations are taken weekly, others monthly, and for some, continuous composite samples of 10 to 15 days are obtained.

Gross alpha and beta measurements are made on both suspended and dissolved solids in the raw surface water samples. The levels of radioactivity associated with dissolved solids provide a rough measure of levels which may be found in a treated water, where such water treatment removes substantially all of the suspended matter. Naturally occurring radioactive substances in the environment are the source of essentially all of the alpha activity. The contamination of the environment from manmade sources is the major contributor to the beta activity. It should be noted that with the cessation of weapons testing, beta activity in most raw waters is generally approaching a level attributable solely to natural beta activity. Natural beta activity can be two or three times the natural alpha activity based on the presence of the same nuclides. Some exceptions to this are seen, notably the data for the Columbia River and the Animas River.

While beta determinations for the first 2 years of the network operation have been conducted on each sample weekly, the alpha determinations are reported generally on a composite sample of more than 1 week. Beginning with samples taken in January 1960, beta determinations were performed on composite samples obtained by combining two weeekly samples. The alpha data will be reported on 3-month composite samples, with one-third of the stations being covered each month. All the data reported in table 1 represent the average of all information available for the month indicated.

Strontium-90 data reported are the results of determinations on composite samples for a 3-month period ending in the month shown.

Additional information and data may be obtained from the following sources:

National Water Quality Network Annual Compilation of Data, PHS Publication. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C. Price $1.50.

Report on National Water Quality Control Network, submitted by Dr. F. J. Weber, Chief, Division of Radiological Health, PHS, at the Joint Committee on Atomic Energy Hearings on Fallout From Nuclear Weapons Tests, Volume 1, May 1959, pages 167–169.

FIGURE 1.—PUBLIC HEALTH SERVICE NATIONAL WATER QUALITY NETWORK SAMPLING STATIONS

As of June 30, 1960

TABLE 1.—RADIOACTIVITY IN RAW SURFACE WATERS

[Concentrations in μμc/liter]

Station	Quarter ending Sept. 30, 1960	November 1960					
		Beta activity			Alpha activity		
	Strontium-90	Suspended	Dissolved	Total	Suspended	Dissolved	Total
Animas River: Cedar Hill, N. Mex.	0.4	4	17	21	7	22	29
Apalachicola River: Chattahoochie, Fla.	.5	0	0	0			
Arkansas River:							
Coolidge, Kans.	.8	0	0	0	3	60	63
Ponca City, Okla.	(1)	0	0	0	1	5	6
Pendleton Ferry, Ark.		100	0	100	20	4	24
Chattahoochie River:							
Atlanta, Ga.		0	1	1			
Columbus, Ga.		0	1	1			
Colorado River:							
Loma, Colo.		0	0	0	1	13	14
Page, Ariz.		39	32	71	13	20	33
Hoover Dam, Ariz.-Nev.	1.0	0	11	11	0	11	11
Parker Dam, Airz.-Calif.		0	6	6	0	10	10
Yuma, Ariz.		0	0	0	2	6	8
Columbia River:							
Wenatchee, Wash.		0	0	0	0	1	1
Bonneville Dam, Oreg.		9	197	206			
Clatskanie, Oreg.	.3	4	94	98	0	1	1
Connecticut River: Northfield, Mass.		0	1	1	0	0	0
Delaware River:							
Martin's Creek, Pa.		0	0	0	0	1	1
Philadelphia, Pa.		0	0	0	2	0	2
Escambia River: Century, Fla.		0	0	0	1	1	2
Great Lakes:							
Gary, Ind.	.5	0	0	0	0	1	1
Duluth, Minn.		0	0	0	0	0	0
Detroit, Mich.		0	0	0	0	0	0
Milwaukee, Wis.		0	<1	<1	0	1	1

[1] Dashes indicate no data reported.

TABLE 1.—RADIOACTIVITY IN RAW SURFACE WATERS—Continued

[Concentrations in μμc/liter]

Station	Quarter ending Sept. 30, 1960	November 1960					
		Beta activity			Alpha activity		
	Strontium-90	Suspended	Dissolved	Total	Suspended	Dissolved	Total
Hudson River: Poughkeepsie, N.Y.	0.1	0	0	0			
Illinois River: Peoria, Ill.	.3	<1	1	2	3	4	7
Kanawha River: Winfield Dam, W. Va.		<1	<1	1	0	1	1
Klamath River: Copco, Oreg.		1	2	3	0	1	1
Little Miami River: Cincinnati, Ohio		0	<1	<1	0	2	2
Mississippi River:							
Red Wing, Minn.	1.4	0	1	1	0	2	2
Dubuque, Iowa		0	14	14	1	1	2
East St. Louis, Ill.		0	0	0	0	3	3
Cape Girardeau, Mo.	.9	8	12	20	3	3	6
West Memphis, Ark.		3	15	18	1	2	3
Delta, La.		0	2	2	1	2	3
New Orleans, La.		0	1	1	1	2	3
Missouri River:							
Williston, N. Dak.		0	2	2	1	5	6
Yankton, S. Dak.	.8	0	0	0	0	7	7
Omaha, Nebr.		8	16	24	3	4	7
St. Joseph, Mo.		0	4	4	7	6	13
Kansas City, Kans.		0	0	0	1	5	6
St. Louis, Mo.	1.2	11	5	16	7	4	11
Ohio River:							
East Liverpool, Ohio	.4	0	0	0	0	1	1
Wheeling, W. Va.	.5						
Huntington, W. Va.		0	0	0	0	1	1
Cincinnati, Ohio		0	0	0	0	0	0
Evansville, Ind.		0	0	0	0	1	1
Cairo, Ill.	.4	7	8	15	<1	1	1
Potomac River:							
Williamsport, Md.		0	0	0	0	0	0
Great Falls, Md.		0	1	1	0	0	0
Red River, North: Grand Forks, N. Dak.	(2)	0	0	0	0	2	2
Red River, South:							
Denison, Tex.		24	9	33	9	45	54
Index, Ark.		0	0	0	1	4	5
Alexandria, La.	1.1	11	3	14	5	4	9
Rio Grande River:							
Alamosa, Colo.		4	0	4	0	2	2
Brownsville, Tex.	.3	4	0	4			
Laredo, Tex.		11	5	16	4	2	6
Sabine River: Ruliff, Tex.		<1	<1	1	1	<1	1
St. Clair River: Port Huron, Mich.	.6	0	0	0	0	1	1
St. Lawrence River: Massena, N.Y.		0	0	0	0	1	1
St. Mary's River: Sault Ste. Marie, Mich.		0	0	0	0	1	1
Schuylkill River: Philadelphia, Pa.		0	0	0	0	0	0
Savannah River:							
Port Wentworth, Ga.	.8	0	50	50			
North Augusta, S. C.		0	0	0	0	0	0
Snake River:							
Wawawai, Wash.	.5	0	4	4	0	3	3
Weiser, Idaho		0	0	0	0	1	1
Susquehanna River:							
Sayre, Pa.	.3	0	4	4	0	<1	<1
Conowingo, Md.	.3	0	0	0	0	1	1
Tennessee River: Chattanooga, Tenn.	.6	0	40	40	0	<1	<1
Yellowstone River: Sidney, Mont.		0	0	0	0	11	11

[2] Insufficient sample for analysis.

Monitoring of Water Supplies Around the Nevada Test Site

By contract with the Atomic Energy Commission, the Public Health Service has conducted an offsite monitoring program around the Nevada Test Site (NTS) since 1955. Included in the program have been measurements of radioactivity in water supplies. These data have been reported in the Atomic Energy Commission's 13th, 14th, 18th, and 23rd Semiannual Reports to Congress and by the Public Health Service in the 1957 congressional hearings, "The Nature of Radioactive Fallout and Its Effects on Man."

Figures 1 and 2 summarize gross beta measurements in water supplies located in the NTS offsite area for September–October and November–December 1960.

The lower limit of detectability with the equipment used is about 10 micromicrocuries per liter.

TABLE 1.—DESCRIPTION OF WATER SAMPLING POINTS, NEVADA TEST SITE

Location	Source	Population served
Las Vegas	13 wells—650 to 1,250′ depth plus Lake Mead supply.	40,000.
Game Reserve	400′ drilled well	20.
Indian Springs	600′ drilled well	Average 250.
Pahrump	75′ driven well	10–50.
Ash Meadows	Spring 25′ deep	8.
Lathrop Wells	3 wells—600′ deep	Average 15.
Beatty	Spring	550.
Lida Junction	125′ drilled well	2–10.
Goldfield	Spring	Average 200.
Tonapah	2 drilled wells—60′ depth	Average 1,500.
Warm Springs	Multiple springs—no improvement.	10.
Diablo	Well	State highway station.
Lincoln Mine	2 driven wells	3.
Caliente	Springs	Average 10–12.
Crystal Springs	Free flowing spring	0.
Alamo	2 wells—50–67′ deep	Average 175.
Pahranagat Lake	Surface	Not used for domestic purposes.
Butler Ranch	Flowing spring	1.
Warm Spring Ranch.	Flowing spring from earth fault.	Public park with swimming pool.
Logandale	Drilled well	300.
Ballistic Range	Drilled well	10–15.

FIGURE 1.—GROSS BETA MEASUREMENTS IN WATER SUPPLIES IN OFFSITE AREAS OF THE NEVADA TEST SITE FOR SEPTEMBER–OCTOBER 1960

[Average concentrations in μμc/liter at time of measurement]

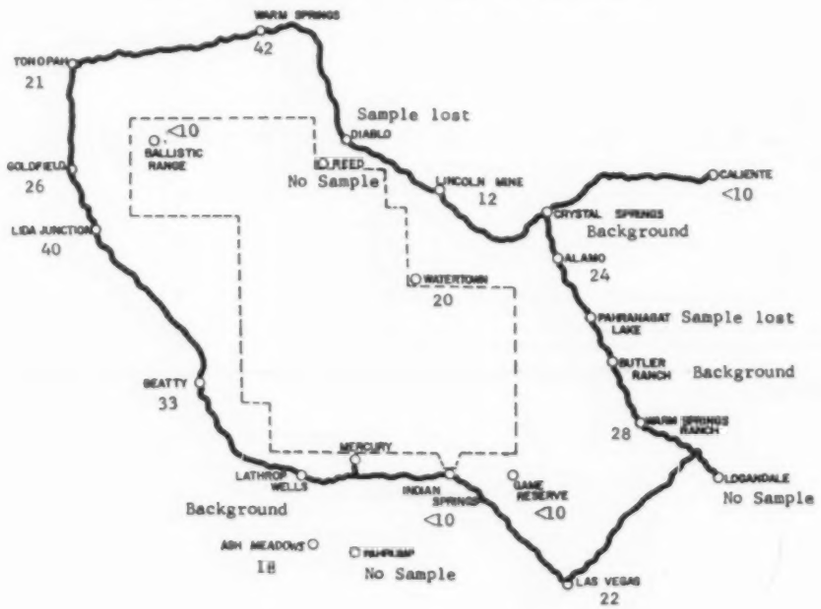
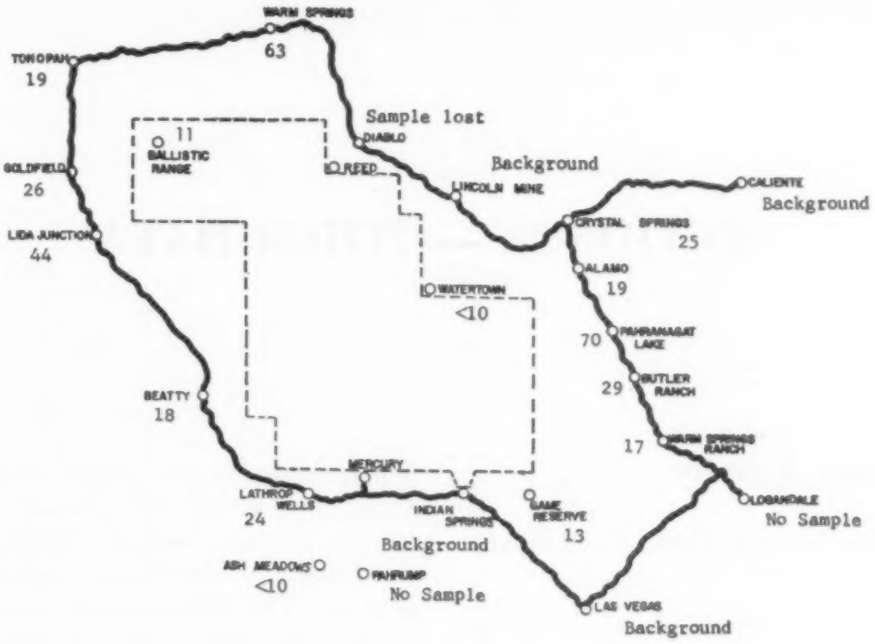


FIGURE 2.—GROSS BETA MEASUREMENTS IN WATER SUPPLIES IN OFFSITE AREAS OF THE NEVADA TEST SITE FOR NOVEMBER–DECEMBER 1960

[Average concentrations in μμc/liter at time of measurement]



SECTION IV.—OTHER DATA

External Gamma Activity

Radiation Surveillance Network, Public Health Service

Portable survey instruments are available at stations of the Radiation Surveillance Network for recording levels of external gamma radiation. Measurements are made daily approximately three feet above the ground. These readings are not precise, but are sufficiently accurate to illustrate any significant variations above background. The differences among the values shown in the following table are within the variance anticipated due to differences in normal background and in instrument response characteristics.

TABLE 1.—EXTERNAL GAMMA ACTIVITY, DECEMBER 1960

Radiation Surveillance Network, Public Health Service

Station location	Average (mr/hr)	Station location	Average (mr/hr)	Station location	Average (mr/hr)
Anchorage, Alaska	0.01	Indianapolis, Ind	0.01	Cincinnati, Ohio	[1]
Fairbanks, Alaska	[1]	Iowa City, Iowa	.02	Oklahoma City, Okla	0.02
Juneau, Alaska	.01	Topeka, Kans	.02	Ponca City, Okla	.04
Phoenix, Ariz	.02	New Orleans, La	.01	Portland, Oreg	.02
Little Rock, Ark	.02	Baltimore, Md	.02	Harrisburg, Pa	.01
Berkeley, Calif	.01	Lawrence, Mass	.02	Providence, R.I	.02
Los Angeles, Calif	.01	Lansing, Mich	.02	Columbia, S.C	.02
Denver, Colo	.02	Minneapolis, Minn	.01	Pierre, S. Dak	.02
Hartford, Conn	.01	Pascagoula, Miss	[1]	Austin, Tex	.01
District of Columbia	.02	Jefferson City, Mo	.01	El Paso, Tex	.02
Jacksonville, Fla	.02	Helena, Mont	.03	Salt Lake City, Utah	.02
Atlanta, Ga	[1]	Trenton, N.J	.02	Richmond, Va	.01
Honolulu, Hawaii	.03	Santa Fe, N. Mex	.04	Seattle, Wash	.02
Boise, Idaho	.02	Albany, N.Y	.02	Cheyenne, Wyo	.02
Springfield, Ill	[1]	Gastonia, N.C	.02	Madison, Wis	.01

[1] No data received.

Factors Contributing to the Occurrence of Radionuclides in Market Milk

St. Louis County Health Department

A discussion of the study of factors contributing to the occurrence of radioactivity in market milk was presented in *Radiological Health Data*, Volume II, No. 3, together with some data on strontium-90 levels in milk and gross radioactivity in animal feeds. The following data, submitted by the St. Louis County Health Department, are further results of their contract with the Research Branch, Division of Radiological Health, Public Health Service. The number of each sampling point in the issue referred to above corresponds to the

sampling point number used in the previous issue. The "digestion coefficient" is the average percentage of each nutrient digested in a particular feed. These values are taken from "Feeds and Feeding," by Frank B. Morrison, The Morrison Publishing Co., Ithaca, N.Y.

TABLE 1.—STRONTIUM-90 IN MILK AND HAY

Sampling point	Milk		Hay					Sampling point	Milk		Hay				
	μμc/liter	μμc/cow/day	Type	μμc/kg	μμc/cow/day	Digestion [1] coeff. (percent)	"Digestible" (μμc/cow/day)		μμc/liter	μμc/cow/day	Type	μμc/kg	μμc/cow/day	Digestion [1] coeff. (percent)	"Digestible" (μμc/cow/day)
1	15.9	229.3	Alfalfa	980	5,911	54	3,190	34	22.6	233.4	Mixed legumes and grasses.	3,570	44,037	[2] 49	21,600
2	15.8	218.8	Red clover and timothy.	252	1,097	[2] 55	603	35	14.9	162.7	Ladino	2,250	20,408	[4] 62	12,700
3	27.4	139.6	Lespedeza	1,340	9,116	50	4,560				Oats	382	3,465	58	
4	29.1	257.6	Mixed grasses	1,100	9,977	52	5,190	36	19.8	138.7	Lespedeza	852	10,394	50	5,200
5	42.0	477.8	Orchard and alfalfa.	1,700	19,274	[2] 54	10,400	37	23.9	181.6	Prairie	1,892	17,847	43	7,670
6	10.6	96.5	Timothy	715	6,810	45	3,070	38	25.3	152.8	Mixed grasses	216	2,038	52	1,060
7	15.9	166.4	Alfalfa	272	4,934	54	2,660	39	23.3	143.9	No sample				
8	12.2	130.7	Alfalfa	755	10,272	54	5,550	40	24.9	209.6	Oats	452	4,746	58	2,750
9	44.4	367.7	Red top and timothy	1,071	13,211	[2 3] 40	5,280	41	24.3	276.5	Lespedeza	3,055	17,319	50	8,660
10	35.5	323.1	Lespedeza	1,920	14,541	50	7,270	42	17.7	158.7	Prairie	746	5,278	43	2,270
11	14.7	167.2	Red clover and timothy.	459	7,827	[2] 55	4,310	43	18.3	158.2	Alfalfa	1,660	12,572	54	6,790
12	20.2	239.0	Alfalfa and prairie.	813	14,748	[2] 48	7,080	44	37.0	331.6	Lespedeza	1,161	16,561	50	8,280
13	21.2	169.8	Timothy	1,077	9,769	50	4,890	45	24.4	259.2	Oat straw, millet and soybean hay.	180	767	[2] 52	399
14	14.0	99.2	No sample					46	26.4	192.2	Red top and timothy.	1,766	8,009	[2 3] 40	3,200
15	21.8	342.4	No sample					47	11.5	76.2	Mixed grasses	900	8,490	52	4,420
16	11.0	153.8	No sample					48	33.0	162.2	Alfalfa	1,435	20,044	54	10,800
17	15.3	163.6	Alfalfa	8,370	111,600	54	60,300	49	12.4	88.0	Lespedeza and wheat.	1,098	18,673	[2] 50	9,340
18	17.8	178.6	No sample					50	7.5	90.2	Red clover	986	28,988	60	17,400
19	6.3	54.5	Alfalfa	369	3,347	54	1,810	51	18.7	221.2	Red clover	664	15,057	60	9,030
20	9.8	111.5	Alfalfa	282	2,878	54	1,550	52	22.0	234.2	Red top and timothy.	1,742	24,649	[2 3] 40	9,860
21	22.6	136.5	Mixed grasses and cottonseed hulls.	1,033	9,370	[3] 49	4,590	53	23.6	214.8	Lespedeza	1,088	4,934	50	5,820
											Timothy	1,972	6,707	50	
22	20.1	166.4	Alfalfa	493	4,069	54	2,200	54	17.5	212.1	No sample				
23	39.7	216.3	Red top	998	9,052	31	2,810	55	11.4	112.8	Prairie	1,052	4,151	43	1,790
24	25.8	92.7	Timothy	1,380	8,950	50	4,480	56	20.7	125.3	Ladino	1,800	27,184	[4] 62	16,900
25	25.4	78.4	No sample					57	16.5	159.6	Alfalfa	537	2,922	54	1,580
26	13.0	124.2	Lespedeza and oats.	1,183	21,460	[2] 54	11,600	58	9.0	53.2	Lespedeza	231	1,571	50	786
27	12.8	111.2	Alfalfa	1,463	19,308	54	10,400	59	15.6	100.1	Alfalfa, ladino, and orchard.	860	9,138	[3 4] 57	5,210
28	30.8	285.9	Lespedeza	1,940	21,995	50	11,000	60	17.5	105.1	Alfalfa	784	8,888	54	4,800
29	12.0	111.4	Lespedeza	1,512	7,817	50	3,910	61	19.1	34.8	Lespedeza	592	3,222	50	1,610
30	22.0	182.2	Lespedeza	1,318	10,879	50	5,440	62	24.2	132.1	Mixed grasses	1,300	11,791	52	6,130
31	35.4	236.8	Lespedeza	2,020	5,405	50	3,060	63	32.4	64.9	Mixed grasses	2,585	17,585	52	9,140
			Timothy	270	722	50		64	29.1	174.6	Oats	387	1,229	58	713
32	35.5	323.1	Lespedeza, red top, timothy.	852	18,161	[2] 44	7,990	65	37.9	344.9	Mixed grasses	1,238	9,545	52	4,960
33	29.5	381.2	Alfalfa	585	1,778	54	8,490	66	12.1	132.1	Lespedeza	2,160	19,592	50	9,800
			Orchard	920	13,936	54									

[1] The digestion coefficient used is the average of the digestion coefficients of the protein, fat, fiber, and nitrogen-free extract obtained from table I in the appendix to the 22d edition of Frank B. Morrison's *Feeds and Feeding* (pp. 1000 to 1070).

[2] The digestion coefficient used is the average of the appropriate values for each of the hays used.

[3] The red top digestion coefficient is derived from the value for mature and weathered western prairie hay, since the two have similar average total compositions (p. 1015).

[4] The Ladino digestion coefficient is derived from the digestion coefficients for Fescue plus Ladino and Fescue (p. 1009).

Strontium-90 Content of Bone in the St. Louis and Nevada Test Site Areas

Research Branch, Division of Radiological Health, Public Health Service

The study of the uptake and retention of strontium-90 in human populations is a vital phase in the proper assessment of the radionuclide hazard to man. Since Sr^{90} is a "bone seeking" fission product, one measure of body burden which has been used extensively is the concentration in human bone expressed in micromicrocuries per gram of calcium. The Public Health Service and the Atomic Energy Commission have initiated large-scale bone-sampling programs in order to estimate the current body burden of Sr^{90}.

The St. Louis and Nevada Test Site areas have been singled out by the Public Health Service as being of primary interest.[1] The levels of Sr^{90}

[1] The Public Health Service bone-sampling program in the NTS area is supported by the AEC.

in milk for the St. Louis area have been consistently higher than those for other stations in the raw milk sampling program. Bones were collected from this area to determine whether the higher level of Sr^{90} in milk would in any way be reflected by Sr^{90} levels in bones of individuals living in this area. It was also recognized that the residents in the vicinity of the Nevada Test Site (NTS) may have been subject to an increased amount of radiation due to fallout from nuclear weapon testing.

At the present time, a total of 126 bone samples has been collected and analyzed (73 from St. Louis and 53 from the NTS areas) over a time period extending from July 1959 to July 1960.

For previous articles on strontium-90 content of human bone, refer to *Radiological Health Data*, Volume 1, No. 2, page 32, and Volume II, No. 1, page 41.

Comparisons of Group Means

The results grouped by age and area are shown in table 1 below.

TABLE 1.—COMPARISON OF STRONTIUM-90 IN HUMAN BONE IN THE ST. LOUIS AND NTS AREAS, 1959–60

Group	St. Louis Area			NTS Area		
	Size of group	Mean (μμc/gm Ca)	95% confidence limits for mean	Size of group	Mean (μμc/gm Ca)	95% confidence limits for mean
Stillborn	8	1.2	1.0–1.4	7	0.6	0.3–0.9
Newborn	9	2.2	1.3–3.1	16	2.0	1.3–2.7
Children 1–5	14	2.2	1.3–3.2	7	1.8	.5–3.1
Children 6–20	14	1.3	0.7–1.9	10	.9	.7–1.2
Adults	28	0.3	.2– .4	13	.4	.2– .6

In general, two types of comparisons can be made from this table. First, the two areas do not vary significantly from each other except for the stillborn group where the St. Louis mean is significantly higher. Second, if the differences between the age groups are examined, a statistically significant difference between the children and adults is nearly always detected (one exception is the stillborn group from the NTS area). However, the confidence intervals are so large that it is not possible to find any significant differences between other age groups. It may be noted that an increase in the size of the newborn and children 1–5 and 6–20 groups would lead to smaller confidence limits which would enable one to detect differences between the groups. The bone-sampling scheme is being expanded with this in mind. Although other bone data are scarce for 1959–60, the means in table 1 agree fairly well with the predicted 1959 averages of Kulp, et al.[1] It would seem, then, that the samples of bone from the St. Louis and NTS areas are not significantly higher in Sr^{90} than those for the rest of the U.S. population.

Strontium-90 Body Burden Predictions

The problem of finding the best theoretical distribution to apply to the Sr^{90}/Ca ratio in bones has been investigated by Libby (1957) and Dahl (1957) with only moderate success. The limited amount of data available made it somewhat difficult to find empirical justification for any postulated mathematical model. Libby has assumed the distribution to be "normal," while Dahl has felt that it is better described as a "log normal" distribution.[2]

The importance of knowing what distribution law describes the experimental data is related to the problem of predicting how many people in a population can be expected to exceed a given burden, or equivalently, what burden will be exceeded by a given small proportion of the population. Any evaluation of risk involves an estimate of the proportion of people having an unusually high skeletal burden. Dahl felt that the experimental data were more nearly log normal and compared the fit using the normal and log normal distributions on a small group of experimental data.

There are three important considerations which lead to the use of "log-normal" theory in fitting this type of experimental data:

1. The observed frequencies are skewed to the left (i.e., there is a greater proportion of people with a smaller burden than would be expected in a normally distributed population).

2. The observed distribution has a relatively long right tail (i.e., there are more people who have higher burdens). Thus, the use of the conventional normal theory leads to seriously underestimating the number of people who would be expected to be found in the higher burden category.

3. In very broad theoretical terms, the log normal model assumes that each ingestion of a

[1] Kulp, J. L., Schulert, A. R., and Hodges, E. J., "*Strontium-90 in Man—IV*" *Science, 132* (1960), 448.

[2] Libby, W. F., "Distribution and Effects of Fallout," *Bulletin of the Atomic Scientists, XIV* (1958), 27.

radionuclide produces an increment in total skeletal burden which is proportional to the burden present at the time of ingestion. The normal distribution only assumes that equal ingestions produce equal increments to total burden regardless of the amount already present in the bone.

The normal and log normal distributions are compared in figures 1, 2, and 3, using data compiled by Kulp, et al.,[1] and the Public Health Service data from the NTS and St. Louis areas. Estimates are given of the body burden which will be exceeded by a small proportion (1 person per 10,000) of the population under the 2 assumptions.

The method used was to plot the data on arithmetic probability and log probability paper which tranforms normal and log normal populations, respectively, into straight lines. Thus, a good fit is indicated by a close conforming of the experimental points to a straight line. Figures 1 to 3 indicate the goodness of fit of the experimental data. In the case of the Western single bone data as presented by Kulp, et al.,[1] the log normal distribution seems to do a much better job of fitting the points, although slight sigmoidal tendencies still exist. Therefore, it appears that the log normal distribution is more satisfactory in the empirical sense.

At the present time, the small amount of Public Health Service data shown in figures 2 and 3 fails to yield conclusive evidence as to the superiority of the log normal distribution. Figures 1, 2, and 3 show the skeletal concentration along the vertical axis and the proportion of people exceeding the given concentration along the horizontal axis. Table 2 below shows the expected concentration which will be exceeded by 1 person per 10,000 in the population at risk for the normal and log normal assumptions.

TABLE 2.—CONCENTRATION TO BE EXCEEDED BY 1 PERSON PER 10,000 UNDER NORMAL AND LOG NORMAL ASSUMPTIONS

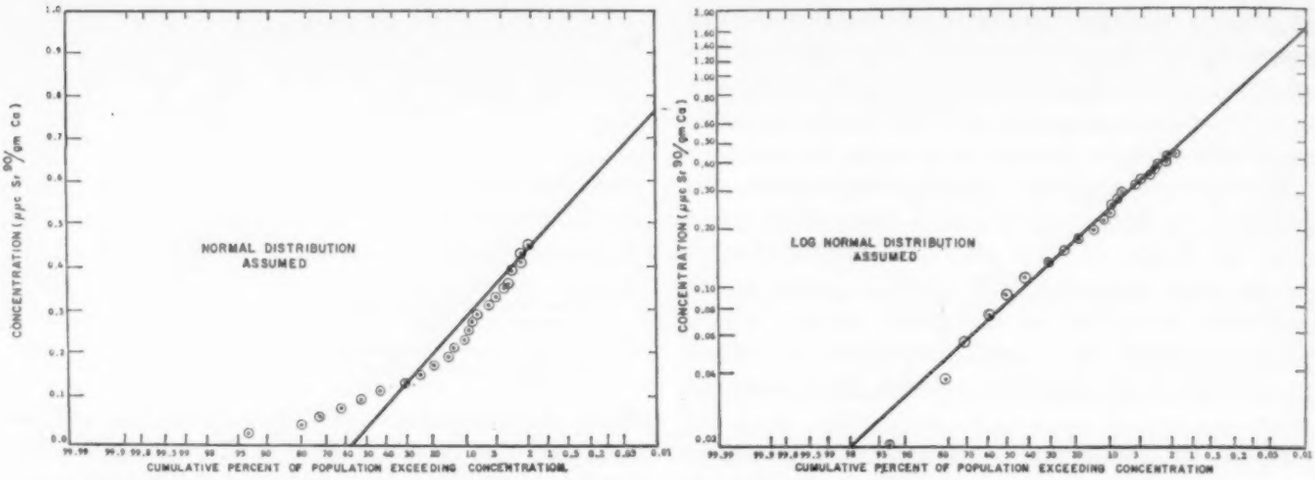
Origin of bone sample	Distribution assumption	Strontium-90 concentration ($\mu\mu$c/gm Ca)
Western single bone	Normal	0.8
	Log normal	1.6
St. Louis-NTS (adults)	Normal	1.2
	Log normal	3.4
St. Louis-NTS (children ages 1–20)[1]	Normal	4.9
	Log normal	20.0
Maximum permissible skeletal concentration for population (ICRP).		67.0

[1] Age groups 1–5 and 6–20 years pooled.

It can be observed that the concentrations predicted by the log normal distribution are higher and thus represent a more conservative approach. In addition, the curvilinear trend at the right tail under the log normal assumption is downward so that a linear extrapolation will overestimate rather than underestimate the proportion of people with very high concentrations. Of course, the normal and log normal are not the only distributions which may provide reasonable models for the population. As a larger volume of data become available, other theoretical distributions are being tested to insure the application of the best model to the population prediction problem.

[1] Kulp, J. S., Schulert, A. R., and Hodges, E. J., "*Strontium-90 in Man—IV*" *Science*, *132* (1960), 448.

FIGURE 1.—WESTERN SINGLE BONE CONCENTRATION* (ADULTS), 1957


NORMAL DISTRIBUTION ASSUMED
CONCENTRATION (μμc Sr 90/gm Ca)
CUMULATIVE PERCENT OF POPULATION EXCEEDING CONCENTRATION
LOG NORMAL DISTRIBUTION ASSUMED
CONCENTRATION (μμc Sr 90/gm Ca)
CUMULATIVE PERCENT OF POPULATION EXCEEDING CONCENTRATION

*See reference 1. (Best fit straight line with more weight given to tail observations.)

FIGURE 2.—ST. LOUIS AND NTS BONE CONCENTRATIONS (CHILDREN), 1959–60

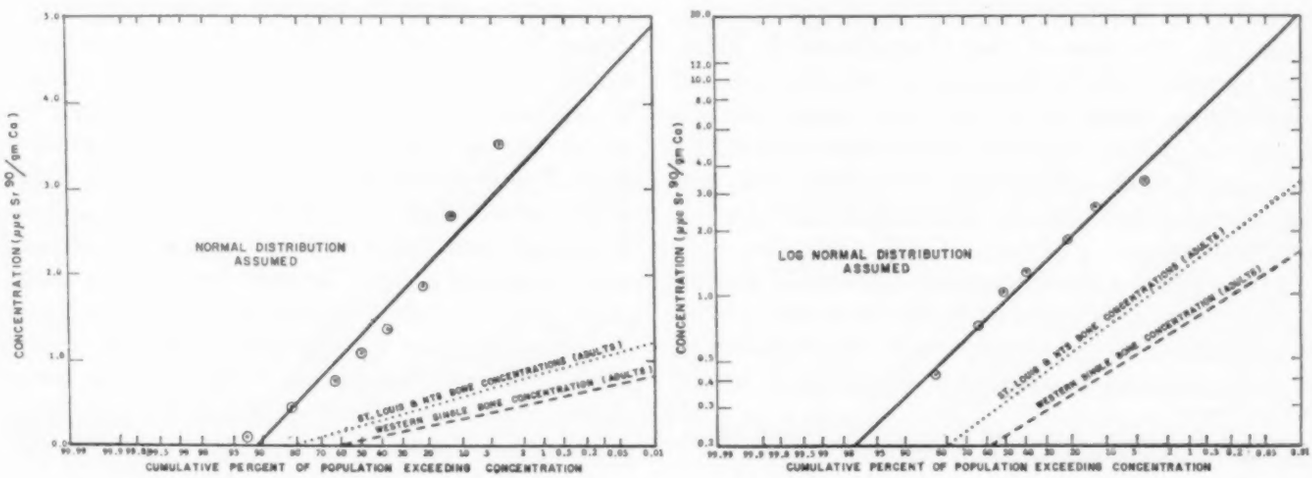
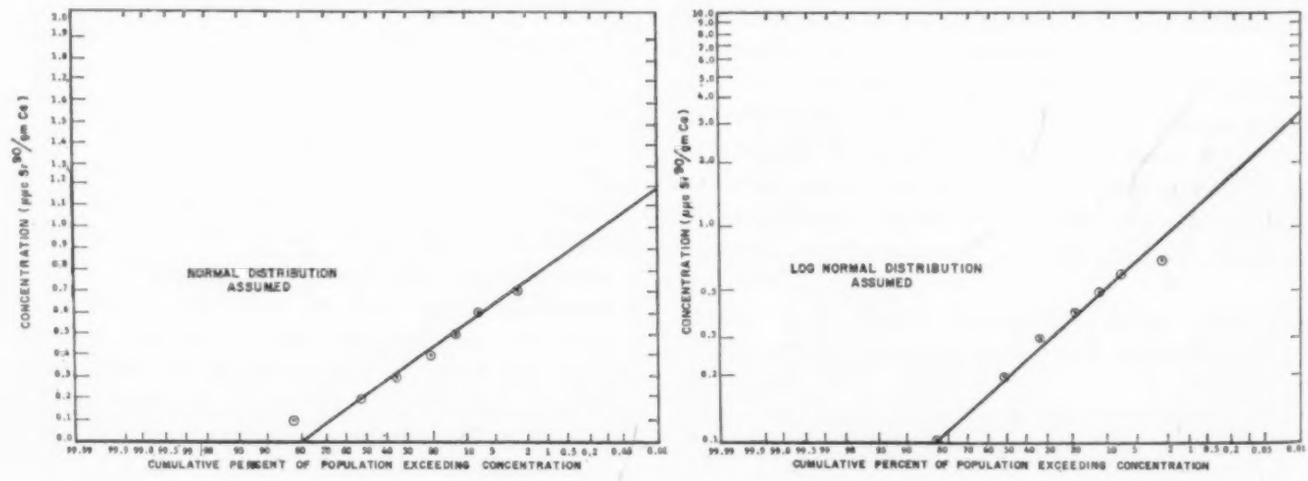

NORMAL DISTRIBUTION ASSUMED
ST. LOUIS & NTS BONE CONCENTRATIONS (ADULTS)
WESTERN SINGLE BONE CONCENTRATION (ADULTS)
CONCENTRATION (μμc Sr 90/gm Ca)
CUMULATIVE PERCENT OF POPULATION EXCEEDING CONCENTRATION
LOG NORMAL DISTRIBUTION ASSUMED
ST. LOUIS & NTS BONE CONCENTRATIONS (ADULTS)
WESTERN SINGLE BONE CONCENTRATION (ADULTS)
CONCENTRATION (μμc Sr 90/gm Ca)
CUMULATIVE PERCENT OF POPULATION EXCEEDING CONCENTRATION

FIGURE 3.—ST. LOUIS AND NTS BONE CONCENTRATIONS (ADULTS), 1959–60


NORMAL DISTRIBUTION ASSUMED
CONCENTRATION (μμc Sr 90/gm Ca)
CUMULATIVE PERCENT OF POPULATION EXCEEDING CONCENTRATION
LOG NORMAL DISTRIBUTION ASSUMED
CONCENTRATION (μμc Sr 90/gm Ca)
CUMULATIVE PERCENT OF POPULATION EXCEEDING CONCENTRATION

ENVIRONMENTAL LEVELS OF RADIOACTIVITY AT ATOMIC ENERGY COMMISSION INSTALLATIONS

The U.S. Atomic Energy Commission is providing data on environmental levels of radioactivity in the vicinity of major Commission installations to the Public Health Service on a quarterly basis. The data are from routine monitoring programs where operations are of such a nature that environmental surveys are required.

Radiological Health Data, Volume I, Nos. 8 and 9; and Volume II, Nos. 1, 2, 3, and 4 contain summaries for 17 installations. Summaries follow for the Hanford Works, the National Reactor Testing Station, and the Savannah River Plant.

Hanford Atomic Products Operation

General Electric Co., Richland, Wash., Issued December 1960

Introduction

During operation of the plutonium production and research facilities at Hanford, controlled amounts of radioactive wastes are released to the atmosphere, ground, and to the Columbia River. The protection of persons living in the neighborhood of the controlled area from radiation exposure attributable to Hanford sources is one of the responsibilities in the operation of the Hanford facilities.

The release of radioactive wastes and environmental radiation levels are summarized for the calendar year 1959 and the first and second quarters of 1960.

Water

The eight production reactors, whose locations are shown in figure 1, contribute radionuclides to the Columbia River water which is used as reactor coolant. More than 60 radionuclides have been identified in the reactor effluent water, and their relative abundance is illustrated in figure 2. Other Hanford facilities do not contribute measurably to the quantity of radionuclides in the river.

Many of the radionuclides in the reactor effluent water are short lived and decay rapidly after formation in the reactors. A gross decay curve, which illustrates this characteristic, is reproduced as figure 3. In addition to radioactive decay, radionuclides are removed from the river water by such mechanisms as silting and uptake by river biota.

Pasco and Kennewick are the nearest cities downstream which treat Columbia River water for use as a public water supply. Finished water (drinking water) from each of the water treatment plants was sampled weekly and analyzed for individual radionuclides or in some cases groups of radionuclides such as the rare earths. Untreated river water at the Pasco pumping plant inlet was also sampled and analyzed weekly. The results of this sampling are summarized in tables 1 and 2.

The finished water of other communities near the plant having sources of water supply other than the Columbia River was periodically sampled and analyzed. Richland, Benton City, Ringold, and Riverview farms are a few of these locations. During a 10-year sampling period, a higher concentration of natural uranium has been noted in the water from Benton City wells than in the water from wells of other local communities.

For the mixture of nuclides present in the river and in finished waters, the gastrointestinal (GI) tract is the organ of major interest. During the period covered by this report, the Pasco population was exposed to less than 7 percent of the maximum permissible concentration in water (MPC_w) for the GI tract. The MPC_w for the population

FIGURE 1.—LOCATION MAP, HANFORD ATOMIC PRODUCTS OPERATION

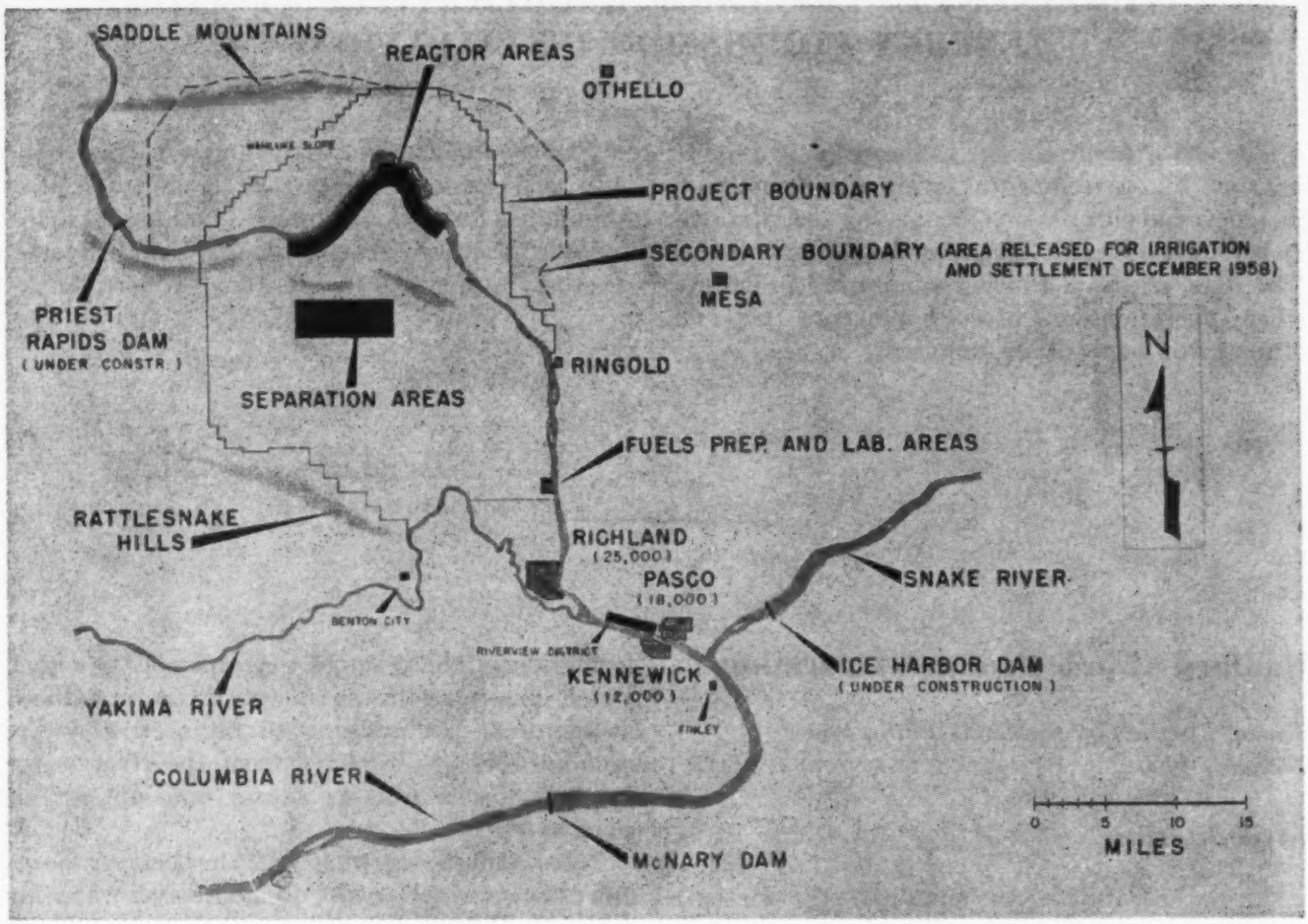
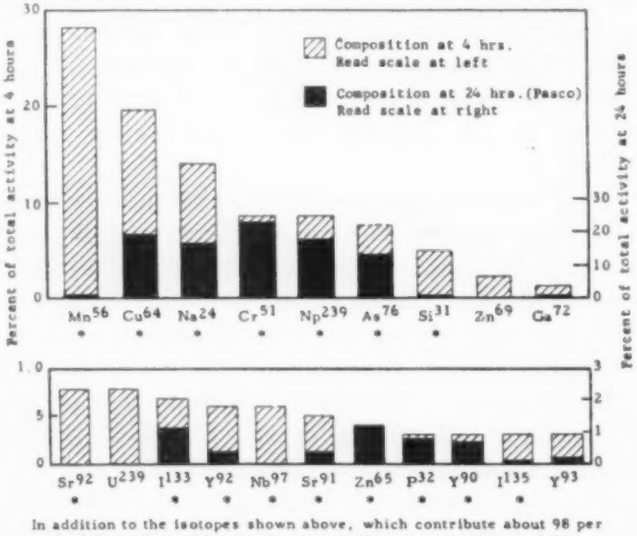


FIGURE 2.—ISOTOPIC COMPOSITION OF REACTOR EFFLUENT 4 HOURS AND 24 HOURS AFTER IRRADIATION

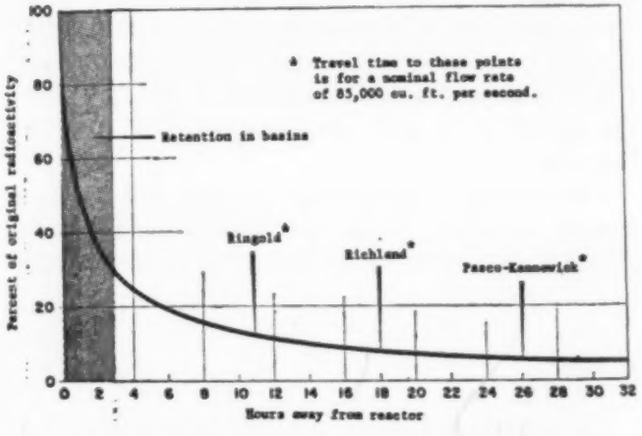

Composition at 4 hrs. Read scale at left
Composition at 24 hrs. (Pasco) Read scale at right
Percent of total activity at 4 hours
Percent of total activity at 24 hours
Mn56 Cu64 Na24 Cr51 Np239 As76 Si31 Zn69 Ga72
Sr92 U239 I133 Y92 Nb97 Sr91 Zn65 P32 Y90 I135 Y93

In addition to the isotopes shown above, which contribute about 98 per cent of the activity 4 hours after irradiation, trace amounts of the following have also been found.

Eu-152	Eu-157	I-131*	Y-91	Pr-145	Cs-137
Sm-153	Ba-140*	Ce-141	Fe-59*	Pm-151	Sr-85
W-187	Mo-99	Pr-142	Sr-89*	Co-60	U-238*
La-141	Sm-156	C-14	Mn-54	Pr-143	Pu-239*
Nd-149	Sc-46*	Nd-147	Zr-95	Ru-103	Ac-227
La-140	Cd-115	Ca-45*	Pm-149	Sc-47	Po-210*
I-132*	Ce-143	Ag-111	Eu-156	Sr-90*	

* Routine measurements are made on these isotopes

FIGURE 3.—REDUCTION IN RADIOACTIVITY OF REACTOR EFFLUENT WITH TIME


Percent of original radioactivity
Hours away from reactor
Travel time to these points is for a nominal flow rate of 85,000 cu. ft. per second.
Retention in basins
Ringold
Richland
Pasco-Kennewick

residing in the neighborhood of a controlled area is one-tenth that given for continuous occupational exposure by NBS Handbook No. 69. Solubility in GI tract and body fluids is assumed. An exposure to less than 2 percent of the MPC_w for the GI tract is estimated for Kennewick residents. The average contribution of several radionuclides to the exposure of the tract would be as illustrated in figure 4.

TABLE 1.—CONCENTRATIONS OF SEVERAL RADIONUCLIDES IN DRINKING WATER

[Average concentrations in $\mu\mu$c/liter]

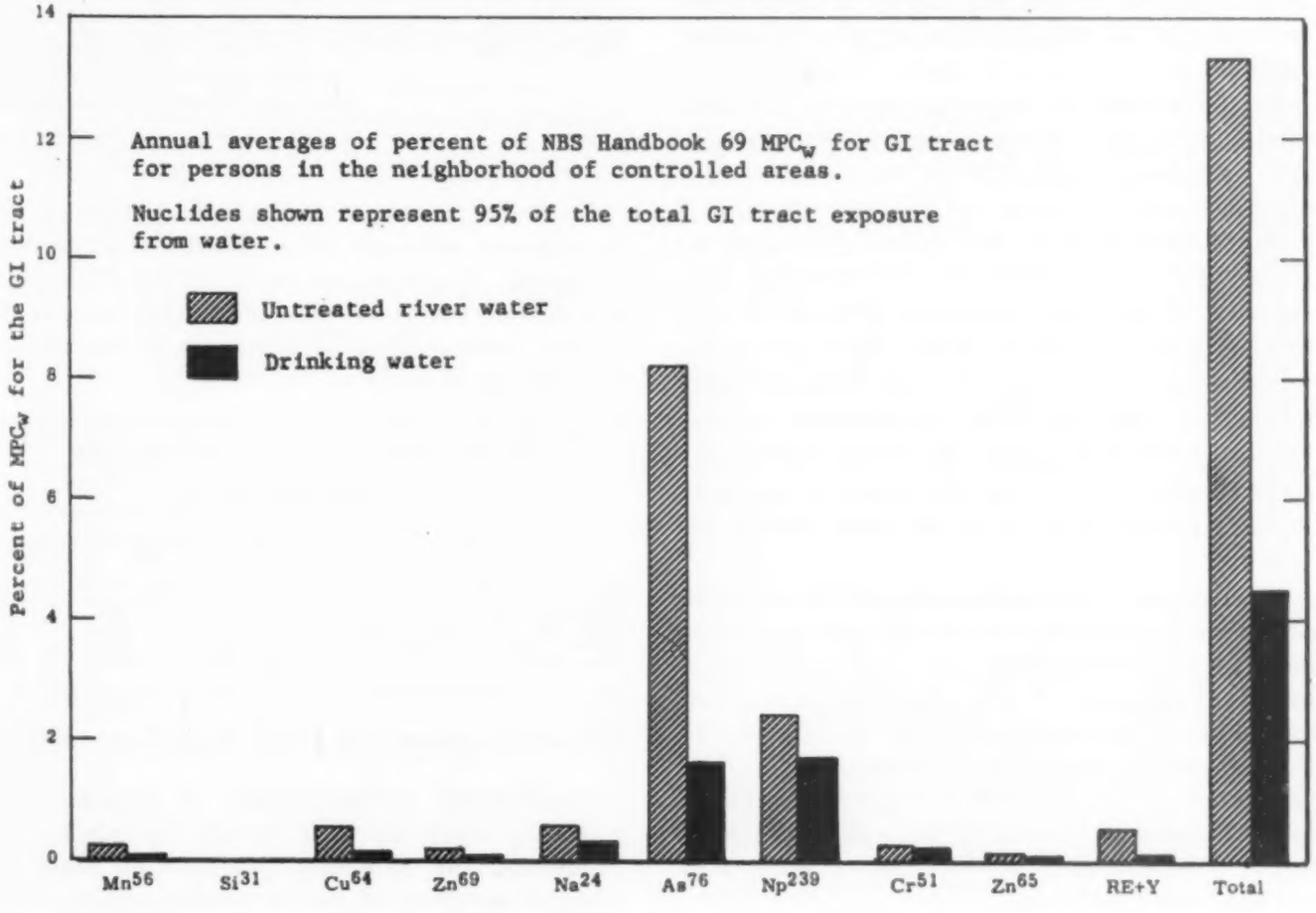
Period	Number samples	Rare earths plus γ	Na^{24}	P^{32}	Cr^{51}	Cu^{64}	Zn^{65}	Zn^{69m}	As^{76}	Sr^{89+90}	Sr^{90}	Np^{239}
Pasco												
1959	52	33	575	35	3,710	340	86	24	340	4.5	0.51	1,500
1st quarter 1960	13	118	359	126	5,770	220	202	13	490	8.1	.37	2,010
2d quarter 1960	11	88	872	21	2,650	500	118	22	210	3.2	.20	1,280
Kennewick												
1959	49	23	151	18	2,080	220	24	18	160	1.0	.26	350
1st quarter 1960	9	33	93	18	3,000	110	25	10	75	.8	.18	280
2d quarter 1960	10	34	150	11	1,530	150	16	14	60	.8	.16	65

TABLE 2.—CONCENTRATIONS OF SEVERAL RADIONUCLIDES IN COLUMBIA RIVER WATER

[Average concentrations in $\mu\mu$c/liter]

Period	Number samples	Rare earths plus γ	Na^{24}	P^{32}	Cr^{51}	Cu^{64}	Zn^{65}	Zn^{69m}	As^{76}	Sr^{89+90}	Sr^{90}	Np^{239}
Pasco												
1959	52	213	1,140	156	4,210	1,620	205	104	1,460	5.3	0.64	2,250
1st quarter 1960	14	689	1,200	1,281	7,190	1,640	417	94	1,510	9.9	.44	4,340
2d quarter 1960	11	606	1,660	130	3,180	2,680	246	222	1,200	3.7	.28	1,790
Vancouver												
1959	8	----	----	31	2,120	----	33	----	----	----	----	179
1st quarter 1960	6	----	----	59	2,750	----	114	----	----	----	----	97
2d quarter 1960	5	----	----	41	1,466	----	90	----	----	----	----	198

FIGURE 4.—PERCENT OF MPC_W FOR THE GI TRACT FOR SELECTED RADIONUCLIDES IN COLUMBIA RIVER WATER AND SANITARY WATER AT PASCO, WASHINGTON—1959



The estimated dose of other organs through water intake is substantially less than that for the GI tract. Some indicative values are compared with the GI tract exposure in table 3.

TABLE 3.—1959 AVERAGE PERCENTAGE MPC$_w$

Location	Type	Percent of $\frac{1}{10}$ MPC$_w$		
		Bone	Total body	GI
Pasco	Inlet water (Columbia River water).	1.6	0.9	15
Pasco	Drinking water	.9	.5	5
Kennewick	Drinking water	.6	.2	2
Vancouver	Columbia River water	.7	.2	----

Several radionuclides contribute to the exposures shown in amounts below the analytical detection limits. In this case, where analytical data permit, the concentrations in the reactor effluent, river depletion rates and river flow data are used to estimate the concentration at a given location. If insufficient data are available for this computation, it is then assumed the radionuclide was present in the concentration represented by the detection limit. Thus the values in table 3 are believed to be upper limits of the estimated exposure.

In the vicinity of Richland, Pasco, and Kennewick, ionization chambers were used to measure the penetrating radiation in the river. Such measurements indicated an annual exposure of about 60 milliroentgens (mr) excluding background for the operators of a ferryboat just upstream from the city of Richland, assuming they spent one-third of their time on the boat. Since the major contributors to the dose, such as Na^{24}, are short lived, the exposure from recreational boating further downstream is less. Swimmers would have received about 15 mr from this source, if they were in the river for as much as 60 hours during the year.

Most of the radionuclides present in the river water which contribute to the GI tract dose have decayed to concentrations too small to be measured at Vancouver, Wash. Radionuclides which contribute to the total body dose and the dose to the bone have decayed to a lesser extent. The calculated percentage of the respective MPC$_w$'s in river water at Vancouver were all of the same order of magnitude; i.e., less than 1 percent of the applicable MPC$_w$'s.

Air

Filter papers from air-sampling stations are changed daily by cooperating agencies. These filter papers are counted for total beta activity. Radioanalyses of filter papers for individual radionuclides is not a routine procedure. However, such an analysis was performed in 1959, during the third quarter. Filter papers from each of 13 locations were grouped for this analysis. Table 4 is a summary of these results corrected for radioactive decay to July 15, 1959. The fact that the concentrations in table 4 are very nearly the same for all locations is evidence that these radionuclides are from fallout.

TABLE 4.—CONCENTRATION OF RADIONUCLIDES ON FILTER PAPERS—THIRD QUARTER 1959

[Average concentrations in $\mu\mu c/m^3$]

Location	Zr^{95}–Nb^{95}	Cs^{137}	Ru^{106}	Ce^{144}–Pr^{144}	Zn^{65}
Benton City, Wash	0.14	0.047	0.16	0.29	----
Richland, Wash	.13	.029	.17	.25	----
Kennewick, Wash	.19	.054	.21	.38	----
Pasco, Wash	.17	.053	.23	.34	0.011
Yakima, Wash	.17	.027	.15	.27	----
Walla Walla, Wash	.14	.029	.15	.29	----
Meacham, Oreg	.10	.031	.11	.26	.009
Lewiston, Idaho	.16	.035	.27	.37	----
Spokane, Wash	.14	.029	.16	.31	----
Boise, Idaho	.20	.044	.27	.50	----
Seattle, Wash	.09	.025	.088	.18	.006
Klamath Falls, Oreg	.14	.032	.22	.30	----
Great Falls, Mont	.14	.037	.15	.25	.011
Average concentration	.15	.0363	.180	.307	.009
Percent MPC$_{air}$ for critical organ	0.001	0.002	0.004	0.01	0.0002

Radiodine has characteristically predominated in gaseous effluents from Hanford separation facilities. Therefore, air sampling for I^{131} in the atmosphere is a routine procedure in several nearby communities. A summary of the results is presented in table 5.

TABLE 5.—ATMOSPHERIC CONCENTRATIONS OF I^{131} AT PERIMETER COMMUNITIES

[Average concentrations in $\mu\mu c/m^3$]

Location	Calendar year 1959	1st quarter 1960	2d quarter 1960
Richland, Wash	0.074	0.046	0.016
North Richland, Wash	.070	.052	.020
Benton, Wash	.157	.056	.010
Pasco, Wash	.129	.027	.012

Concentrations in Food and Vegetation

Atmospheric concentrations of radionuclides generally result in their uptake by plant life. Therefore, the sampling program at Hanford includes sampling of native grasses, grain, vege-

tables, fruits, alfalfa, milk, and other materials from the biosphere such as jackrabbit thyroid. These data are not summarized here but will be published separately in a subsequent issue of *Radiological Health Data*.

Conclusions

It is concluded from the data that the estimated exposure of persons residing in the neighborhood of the Hanford controlled area approximates 10 to 15 percent of the applicable limits recommended by the National Committee on Radiation Protection.

Hanford's contribution to environmental exposure through atmospheric paths is considerably less than that due to fallout from nuclear detonations. Atmospheric contributions are small compared to the contribution through water effluents.

National Reactor Testing Station

Health and Safety Division, Atomic Energy Commission, Idaho Falls, Idaho, Issued December 1960 and February 1961

Environmental levels of radioactivity at the National Reactor Testing Station (NRTS) have been reported in *Radiological Health Data*, Volume I, No. 9, and Volume II, No. 2. The following report presents the data for the third and fourth quarters, 1960.

Safe operation of the National Reactor Testing Station, without radiation hazard to the public or the environment, continued during the third and fourth quarters.

Table 1 summarizes data for radioactivity in water, air, rabbit bones, and milk sampled at more than 200 locations on, near, and within 115 miles radius of the NRTS.

Figure 1 details the locations and types of sampling. It will be noted that air monitoring is concentrated to the northeast, and water monitoring is to the southwest of the NRTS. This is in accordance with the prevailing wind direction and the local underground water gradient for this region. Periodic evaluations of the program are made, and adjustments in location and sampling frequency will be made in subsequent reports.

The minimum detection limit used in connection with iodine-131 in milk is now 200 $\mu\mu$c/liter. This reflects an improvement in the analytical method, which increases the sensitivity of this procedure by a factor of 5 over that previously used.

TABLE 1.—RADIOACTIVITY IN WATER SUPPLIES

[Average concentrations in $\mu\mu$c/liter]

Type of supply	Number of stations	Sampling frequency	3d quarter 1960			4th quarter 1960		
			Number of samples	Alpha	Beta	Number of samples	Alpha	Beta
Offsite ground water	29	Bimonthly	50	<3.1	<150	28	<3.1	<150
Onsite production well water	22	Weekly	200	<3.0	<160	208	3.0	<150

TABLE 2.—GROSS BETA RADIOACTIVITY IN OFF-SITE AIR

Period 1960	Sampling frequency	Number of stations	Number of samples	Average concentrations ($\mu\mu$c/m^3)
3d quarter	Weekly	10	138	1.3
4th quarter	Weekly	10	117	1.4

TABLE 3.—STRONTIUM-90 IN JACKRABBIT BONES[1]

Location	Number stations	Sampling frequency	3d quarter 1960		4th quarter 1960	
			Number samples	Average concentration ($\mu\mu$c/gm Ca)	Number samples	Average concentration ($\mu\mu$c/gm Ca)
Perimeter	10	Quarterly	9	16	11	9
Offsite	10	Quarterly	25	15	20	13

[1] Analyses are for the previous quarter.

TABLE 4.—OFFSITE MILK MONITORING FOR IODINE-131

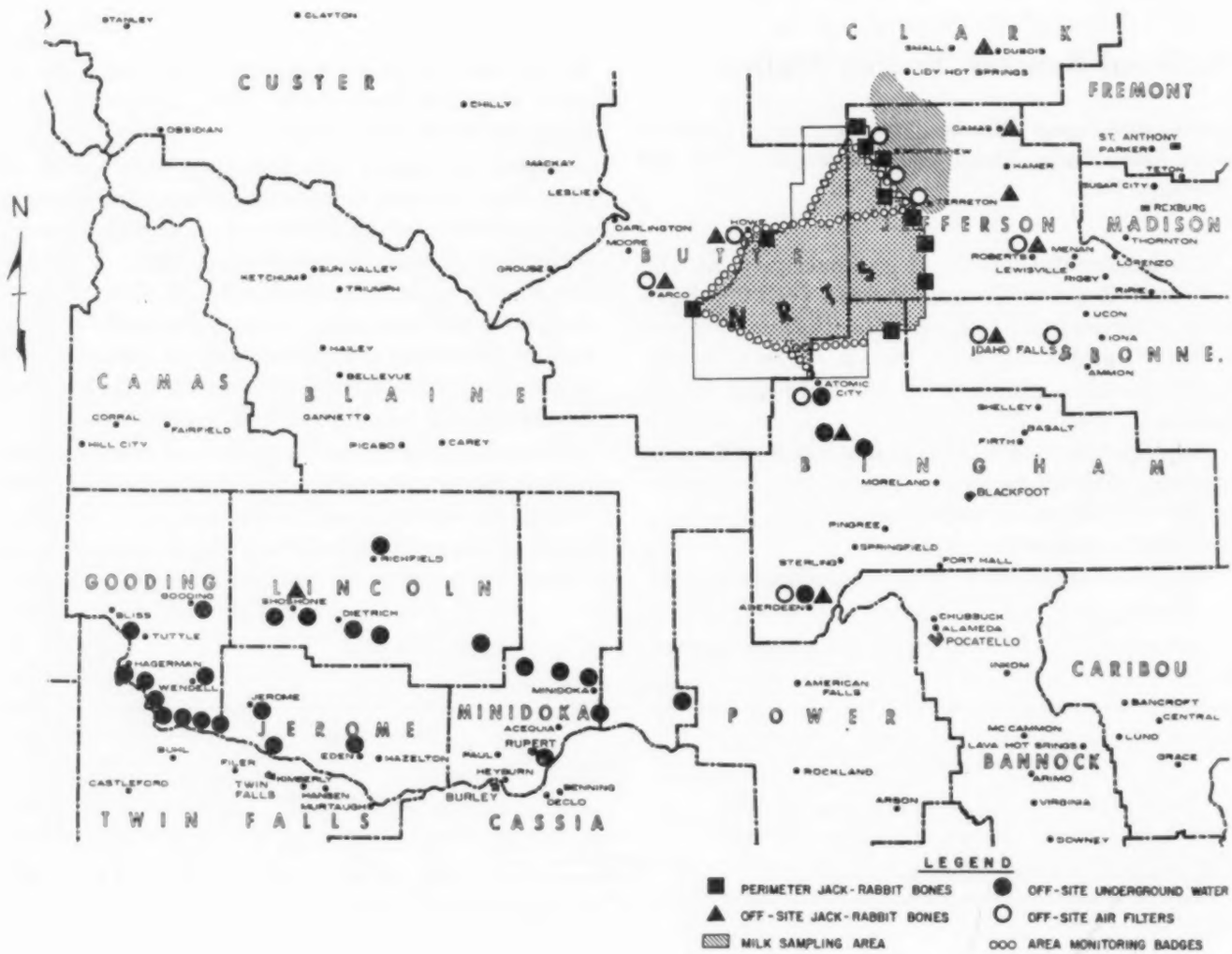
Period (1960)	Sampling frequency	Number stations	Number samples	Average concentration (μμc/liter)
3d quarter	Monthly	30	317	<200
4th quarter	Monthly	30	343	<210

TABLE 5.—OFFSITE FILM BADGE MONITORING

[Dose in mrem/90 days]

Period (1960)	Sampling frequency	Number stations	Number samples	Beta	Gamma
3d quarter	Monthly	118	108	10	10
4th quarter	Monthly	118	340	10	20

FIGURE 1.—ENVIRONMENTAL MONITORING STATIONS, NATIONAL REACTOR TESTING STATION



Savannah River Plant

E. I. du Pont de Nemours Co., Aiken, S.C., Issued February 9, 1961

Environmental levels of radioactivity at the Savannah River Plant for 1959 and the first quarter of 1960 were reported in *Radiological Health Data*, Volume 1, No. 9. The following report presents a summary of the data for the second and third quarters of 1960.

The Savannah River Plant maintains a continuous monitoring program to determine the concentrations of radioactive materials in a 1,200-square-mile area outside the plant perimeter. Included in this area are parts of Aiken, Barnwell, and Allendale Counties in South Carolina, and Richmond, Burke, and Screven Counties in Georgia. This program, initiated in 1951 prior to startup of the plant, is carried out by the Health Physics Section of the Du Pont Co. The purposes of the program are to measure the background at the site, to determine the magnitude and origin of any radioactivity above the natural levels and, of primary interest, to insure that any radioactive materials released to the environment by plant operations are below the Radioactivity Concentration Guides (RCG) for large populations specified by the Federal Radiation Council.

A basic principle of plant operations is total containment of radioactive waste. Although some varied low level gaseous and liquid wastes are disbursed within the environment in controlled releases, the disbursal is adequate to insure that the concentration is well below the RCG levels. The RCG is a benchmark against which environmental contamination levels can be evaluated. The survey data presented in this report provide information which is useful both to measure the effectiveness of plant controls and as evidence of the strict adherence to the recommended RCG levels.

Very sensitive instruments, which can detect traces of radioactive materials several orders of magnitude below that of hazard significance, are used to determine the levels of radioactivity in the environs. Frequently, radioactivity could not be detected in environmental samples. In such instances, a minimum amount that can be accurately detected by the analysis is used in determining the average concentrations. These values (sensitivity of analysis) are presented with the data. In most cases, possible radioactivity contributed by the plant was either so small it was less than that which exists naturally or it was obscured by fallout which resulted from nuclear weapons testing. Since radioactive materials contributed by each of these sources cannot be readily separated or interpreted in terms of origin, all are included in the reported concentrations.

Atmospheric Monitoring

A comprehensive surveillance of levels of radioactivity in the atmosphere was carried out by weekly analyses of air and rain water samples collected continuously at 13 monitoring stations, including 5 locations at the plant perimeter. These stations, forming two concentric circles around the plant, are spaced so that a significant plant release of radioactivity to the air would be detected regardless of prevailing wind conditions (see fig. 1). Four continuous air monitoring stations were installed during the report period at locations approximately 100 miles from the plant. These distant stations, operated at Savannah and Macon, Ga., and Columbia and Greenville, S.C., serve as "reference points" for determining background levels of radioactivity in air. The location of the 100-mile-distant stations in relation to the Savannah River Plant are shown in figure 2. An average level of radioactivity at the plant perimeter substantially higher than that observed at the 25-mile and 100-mile radii would be indicative of a plant contribution, since weapons debris arriving from distant test sites would be widespread and more evenly disbursed. Small differences in average radioactivity levels, however, are attributed both to nonuniformity of fallout and to statistical variation of the analyses. Table 1 summarizes the air monitoring data.

TABLE 1.—GROSS RADIOACTIVITY IN AIR

[Average concentrations in $\mu\mu c/m^3$]

Location	2d quarter 1960			3d quarter 1960		
	Alpha	Non-volatile beta	Radio-iodine	Alpha	Non-volatile beta	Radio-iodine
Plant perimeter	0.0025	0.24	0.04	0.0009	0.09	<0.04
25-mile radius	.0011	.18	.04	.0007	.07	<.04
100-mile radius	------	------	------	.0012	.06	------
Percent of RCG at plant perimeter	6.3	0.24	0.01	2.2	0.09	0.02
Sensitivity of analysis	.0003	.013	0.04	0.0004	0.008	0.04

FIGURE 1.—SAMPLE COLLECTION STATIONS, SAVANNAH RIVER PLANT

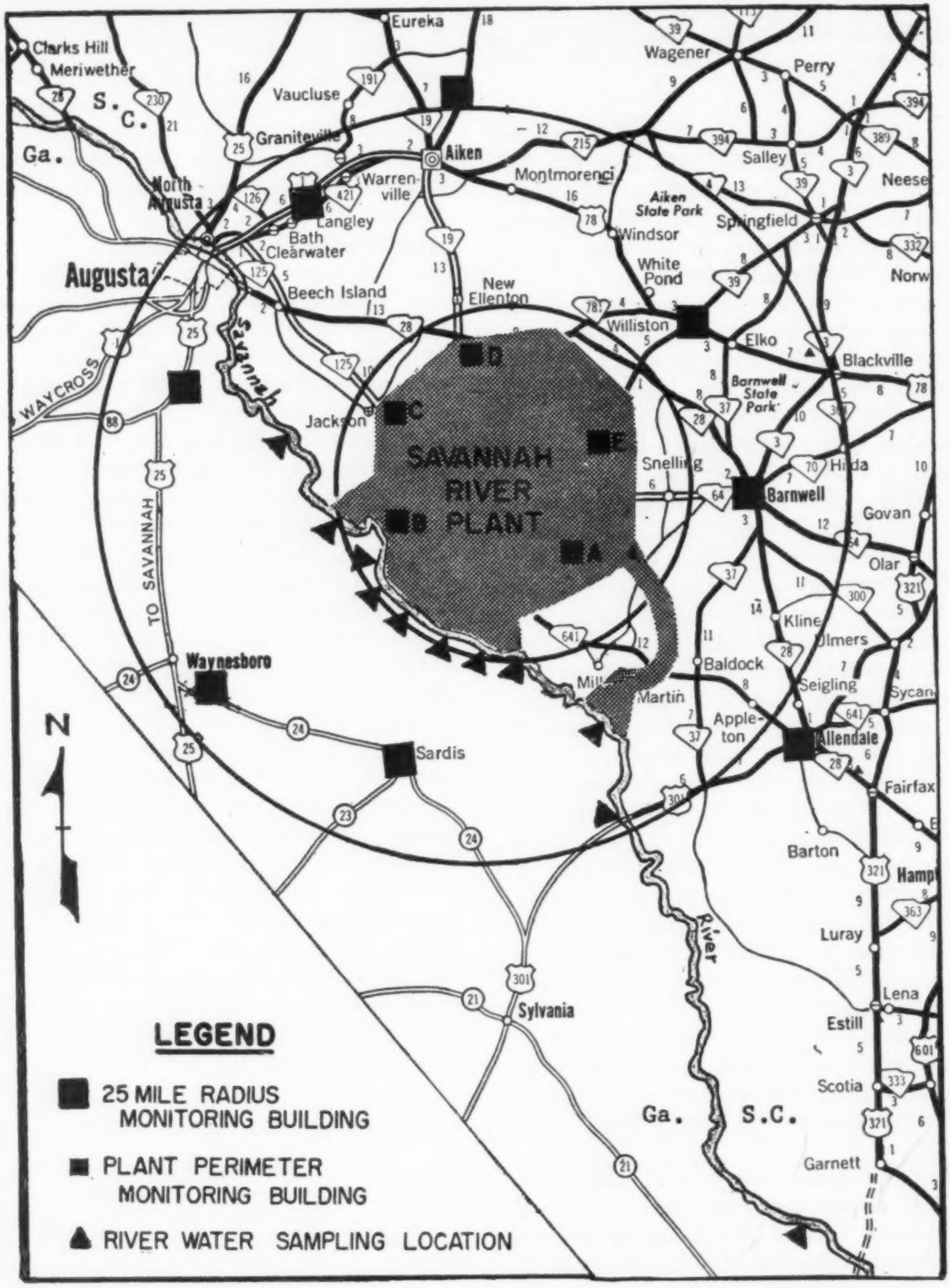


FIGURE 2.—DISTANT AIR MONITORING STATIONS, SAVANNAH RIVER PLANT

TABLE 2.—GROSS RADIOACTIVITY IN RAINWATER

[Average concentrations in μμc/liter]

Location	2d quarter 1960			3d quarter 1960		
	Alpha	Nonvolatile beta	Radioiodine	Alpha	Nonvolatile beta	Radioiodine
Plant perimeter	0.7	50	14	0.6	28	<7
25-mile radius	.6	50	15	.4	20	<8
100-mile radius						
Percent of RCG [1] at plant perimeter	7.0	1.7	0.7	6.0	0.9	1.0
Sensitivity of analysis	0.1	7	15	0.2	4	

[1] Assuming use as drinking water.

The average concentration of atmospheric radioactivity during the second quarter of 1960 generally showed an increase over 1959 and first quarter 1960 values. The third quarter showed a marked reduction in values. A release of airborne radioactivity from the manufacturing area during the 7-day period ending June 15, 1960, was evident at one monitoring station near the plant perimeter but not at any offsite monitoring locations. This single release increased the average concentrations of alpha and nonvolatile beta emitters at the plant perimeter during the report period, with no hazards to personnel.

The increase during the second quarter in the nonvolatile beta emitters in air, as reflected by the concentrations at the 25-mile radius, was due to the large-scale upper air motions that caused maximum deposition of nuclear weapons test debris from the stratospheric reservoir during the spring months.

The environmental radioiodine was so low during the third quarter that no radioiodine was found in the 642 environmental samples (air, rainwater, and vegetation) analyzed using sensitive radiochemical procedures.

Environmental Gamma Radiation Levels

Continuous measurements were taken at each of 13 monitoring buildings, as shown in figure 1, to determine the gamma radiation level. Plant operations were found to have had no measurable effect on the gamma radiation levels. The average dose rates at the perimeter locations and at the 25-mile-radius locations were no higher than those expected from natural sources alone. These values, almost identical with those obtained during previous quarters, are consistent with external gamma radiation levels recorded at all of o f stations of the Public Health Service Radiation Surveillance Network in March 1960.

Water Monitoring

The communities in the vicinity of the Savannah River Plant obtained their drinking water from deep wells or small surface streams. The results of public water samples collected monthly from 14 surrounding towns which are shown in table 3 are essentially the same as those observed prior to startup of the Savannah River Plant before 1951.

TABLE 3.—RADIOACTIVITY IN PUBLIC WATER SAMPLES

[Average concentrations in μμc/liter]

Analysis	2d quarter 1960			3d quarter 1960		
	Sensitivity of analysis	Concentration	Percent RCG	Sensitivity of analysis	Concentration	Percent RCG
Alpha	0.1	1.0	10	0.2	0.7	7
Nonvolatile beta	7	7	.2	4	6	.2

The close agreement of these data with the results obtained prior to startup shows no effect due to plant operations and only a slight increase due to nuclear weapons fallout in water supplies that utilize surface streams.

Savannah River water was sampled continuously at one location immediately upstream from the plant and at one location downstream from

the plant (at the Highway 301 crossing). The results of weekly analyses of these samples were supplemented by analyses of "grab" samples collected each week at eight river locations along the plant boundary and at one location 60 miles downstream from the plant (Stokes Bluff Landing).

Quarterly average concentrations of radioactivity in Savannah River water as shown in table 4 indicate that plant operations contribute small amounts of radioactivity to the river, but the resulting concentrations are far below RCG values.

TABLE 4.—RADIOACTIVITY IN SAVANNAH RIVER WATER

[Average concentrations in μμc/liter]

Location	2d quarter 1960				3d quarter 1960			
	Alpha	Non-volatile beta	H^3	Sr^{90} [1]	Alpha	Non-volatile beta	H^3	Sr^{90} [2]
3 miles above plant	0.3	7	4,000	0.4	0.2	6	4,000	0.3
At plant boundary	.5	21	-------	-------	.3	19	-------	-------
10 miles below plant	.4	26	8,000	.7	.2	27	9,000	.5
Percent of RCG at 10 miles downstream	4.0	0.9	0.3	2.1	2.0	0.9	0.3	1.5
Sensitivity of analysis	0.2	7	4,000	0.1	0.2	4	4,000	0.1

[1] These averages include samples collected during March, April, and May, 1960.
[2] These averages include samples collected during June, July, and August, 1960.

Vegetation and Food Monitoring

The sampling program included collection of vegetation from 14 locations along the plant perimeter and at 14 locations along the 25-mile-radius route. Bermuda grass was selected for sampling because of its importance as a pasture grass for dairy herds and because of its availability during all seasons of the year.

The average concentrations of radioactivity in vegetation are shown in table 5. The fact that the concentrations are very nearly the same at the plant perimeter and along the 25-mile radius is evidence that plant contributions are negligible and that the radioactivity being measured is attributed to fallout and natural sources. An apparent downward trend of radioactivity was observed in vegetation as shown by the results. The decreased alpha activity is consistent with previously observed seasonal variations, while the beta radioactivity reflects decreased fallout.

TABLE 5.—RADIOACTIVITY IN BERMUDA GRASS SAMPLES

[Average concentrations in μμc/gm dry weight]

Location	2d quarter 1960			3d quarter 1960		
	Alpha	Non-volatile beta	Radio iodine	Alpha	Non-volatile beta	Radio-iodine
Plant perimeter	0.12	20	0.7	0.10	14	---------
25-mile radius	.13	30	.7	.11	12	---------
Sensitivity of analysis	.06	4	.7	.1	2	---------

Milk from dairies and farms in Aiken, North Augusta, Snelling, Talatha, and Langley, S.C., was analyzed weekly for radioiodine and tritium content. The average radioiodine concentration in the samples collected during the second quarter was less than the minimum sensitivity of the analysis which is equivalent to 25 percent of the RCG. The average tritium concentration during this quarter was approximately 5,000 micromicrocuries per liter. This concentration is approximately 2 percent of the RCG.

An improved radioiodine analysis of milk samples, adopted during the third quarter in 1960, allowed detection of concentrations equivalent to 0.5 percent of the RCG. Even with this substantially lower detection limit, the quarterly average radioiodine concentration in milk samples was less than the minimum sensitivity of the analyses (9 μμc/liter). The results for analyses of milk samples for tritium during the third quarter were unchanged from those of the second quarter.

Quarterly determinations of strontium-90 content were performed on milk produced locally. In addition to the sampling points mentioned previously, milk from local farms and dairies in Williston and Brogdon, S.C., and Sylvania, Ga., was sampled and analyzed. Average concentrations detected in milk samples during the second quarter were 11.5 μμc/liter and during the third quarter, 14.5. These concentrations are attributed entirely to the accumulation of strontium-90 fallout from previous nuclear weapons tests. The results are slightly less than those reported by the Public Health Service Raw Milk Sampling Station at Atlanta, Ga.[1]

Milk collected from farms where only one or two cows produce for domestic consumption contained more strontium-90 than milk collected from local dairies. Such differences are attributed

[1] *Radiological Health Data*, Volume I, No. 7, October 1960.

to different methods of feeding, the dairy herd being partially stall fed with nonfodder supplements and the "family cow" subsisting almost entirely on pasture grass.

The determination of radioactivity concentrations in algae is important because they are well-known concentrators of specific radioactive materials and because of their relationship in the food chain of aquatic organisms. Indigenous algae, primarily green (*Vaucheria*) and blue-green (*Phormidium*), were collected weekly upstream from, adjacent to, and downstream from the plant. The results are shown in table 6. These concentrations show some correlation with those in the plant effluent as it discharges into the river, since the average concentrations of nonvolatile beta emitters in algae upstream were less than that downstream.

TABLE 6.—RADIOACTIVITY IN SAVANNAH RIVER ALGAE

[Average concentrations in μμc/gm dry weight]

Location	Nonvolatile beta emitters	
	2d quarter 1960	3d quarter 1960
3 miles upstream from plant	25	25
At plant boundary	123	65
10 miles downstream	104	60

Fish, predominantly bream and catfish, were collected weekly above, adjacent to, and below the plant. The average levels of radioactivity observed are presented in table 7. The quarterly average nonvolatile beta concentrations measured in the edible portion (flesh) showed no plant concentrations are attributed to naturally-occurring potassium-40.

TABLE 7.—RADIOACTIVITY IN FISH FLESH

[Average concentrations in μμc/gm wet weight]

Location	Nonvolatile beta emitters	
	2d quarter 1960	3d quarter 1960
3 miles upstream from plant	4	3
At plant boundary	5	4
60 miles downstream from plant	4	4

General Conclusion

The concentrations of radioactive materials found in the environs of the Savannah River Plant during the second and third quarters of 1960 were, like the first quarter, too low to be distinguished from natural background or from bomb debris from past weapons tests. Exceptions are minor radioactivity concentrations having no health significance in the water and aquatic organisms of the Savannah River.

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